FIFTEENTH ANNUAL

REPORT

OF

RUTGERS SCIENTIFIC SCHOOL,

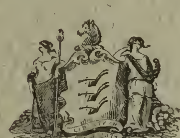
THE STATE COLLEGE,

FOR THE

BENEFIT OF AGRICULTURE AND MECHANIC ARTS,

NEW BRUNSWICK, N. J.,

FOR THE YEAR 1879.



TRENTON, N. J.:
WM. S. SHARP, PRINTER AND STEREOTYPER.
1879.

FIFTEENTH ANNUAL

REPORT

OF

RUTGERS SCIENTIFIC SCHOOL,

THE STATE COLLEGE,

FOR THE

BENEFIT OF AGRICULTURE AND MECHANIC ARTS

NEW BRUNSWICK, N. J.,

FOR THE YEAR 1879.

TRENTON, N. J.:
WM. S. SHARP, PRINTER AND STEREOTYPER.
1879.

CONTENTS.

BOARD OF VISITORS.

First Congressional District.

	Residences.	*Terms Expire.*
Hon. THOMAS H. DUDLEY,	Camden,	April 12, 1880.
CHALKLEY ALBERTSON, Esq.,	Haddonfield,	April 12, 1880.

Second Congressional District.

Hon. WILLIAM PARRY,	Cinnaminson,	April 12, 1881.
EDWARD J. C. ATTERBURY, Esq.,	Trenton,	April 12, 1880.

Third Congressional District.

Hon. WILLIAM A. NEWELL,	Allentown,	April 12, 1880.
JAMES NEILSON, Esq.,	New Brunswick,	April 12, 1880.

Fourth Congressional District.

JOHN DEMOTT, Esq.,	Middlebush,	April 12, 1881.
WM. R. JANEWAY, Esq.,	Franklin Township,	April 12, 1880.

Fifth Congressional District.

WILLIAM HILLIARD, Esq.,	Peapack,	April 12, 1881.
NATHAN H. DRAKE, Esq.,	Flanders,	April 12, 1880.

Sixth Congressional District.

PATRICK T. QUINN, Esq.,	Newark,	April 12, 1880.
WILLIAM M. FORCE, Esq.,	Newark,	April 12, 1881.

Seventh Congressional District.

ABRAHAM S. DURYEA, Esq.,	New Durham,	April 12, 1880.
Prof. ALBERT K. LEEDS,	Hoboken,	April 12, 1880.

OFFICERS.

Hon. WILLIAM PARRY, *Chairman.*
Prof. GEORGE H. COOK, *Secretary.*

REPORT OF STATE BOARD OF VISITORS.

Fifteenth Annual Report of the Board of Visitors to the State Agricultural College.

To His Excellency Geo. B. McClellan, Governor of the State of New Jersey:

Sir—Herewith the Board of Visitors of the State Agricultural College present their fifteenth annual report on the present condition and course of instruction in the College, as required in the act creating the board, entitled "An act appropriating scrip for public lands granted to the State of New Jersey by the act of Congress approved July 2d, 1862," and approved April 4th, 1864.

In accordance with the law, two meetings of the board have been held at the College during the year; and at these meetings the examinations of the students have been attended, their work has been examined, and the laboratories, draughting-room, museum and lecture and recitation-rooms have been visited.

Their first meeting was held December 13th, 1878, at which Messrs. Parry, Atterbury, Dudley, Duryea, Force, Garrabrant, Janeway, Leeds, Neilson and Newell were present. The examinations attended were:

Seniors—Organic Chemistry, by Prof. Cook.
" Analytical Mechanics, by Prof. Bowser.
Juniors—Constitutional History of the U. S., by Prof. Atherton.
Sophomores—Descriptive Geometry, by Prof. Hasbrouck.
" Chemistry, by Prof. Van Dyck.
" Surveying, by Prof. Bowser.
Freshmen—French, by Prof. Meyer.

Students from all the classes were examined in Analytical Chemistry by Prof. Austen, and in Draughting by Prof. Hasbrouck.

At the close of the examination the board held their meeting, at which the course of instruction was considered, and also the progress of the students in their studies, and it was resolved that the various classes had made commendable progress in their studies, and that the Trustees of Rutgers College were faithfully and liberally fulfilling their engagements to the State.

The board also discussed the importance of an agricultural experiment station for the State, in connection with the farm and laboratories of the College, and it was resolved that the board in a body would go before the Legislature at its coming session, and ask for the passage of a law and appropriation for the establishment and support of such a station.

It was reported at this meeting that there were twenty of the State scholarships filled, and that the remaining twenty were vacant. In consideration of the value and importance of these scholarships to the people of the State, it was directed that authority be asked from the Legislature to publish, in a suitable manner, these vacancies, so that young men seeking education in liberal and practical science, may enjoy their advantages.

The second meeting was held June 10th, 1879.

At this meeting were present, Messrs. Albertson, Demott, Dudley, Duryea, Force, Leeds, Janeway and Newell. The following examinations were attended, viz.:

Juniors—International Law, Prof. Atherton.
Sophomores—Descriptive Geometry, Prof. Hasbrouck.
" Railroad Curves, Prof. Bowser.
Freshmen—Botany, Prof. Van Dyck.
" Trigonometry, Prof. Hasbrouck.

All the classes were examined in Analytical Chemistry by Prof. Austen, and in Draughting by Prof. Hasbrouck.

A meeting of the board was held after the examination, and a full and free interchange of opinions in regard to the examination was had. A resolution of approval of the instruction and of the progress of the students, was passed. And another expressing their judgment that the Trustees of Rutgers College are fulfilling their contract with the State in the most liberal manner.

Mr. Dudley reported that the application of the board to the Legislature, for the establishment of an agricultural experiment station on the College farm, had not been granted. A large number of the members of the board had appeared before the committees of the two Houses, and their petition was unanimously approved by both committees, and they reported a bill to that effect, but it failed to pass the Senate.

It was resolved that the board, retaining their opinion of the great usefulness of such a station to the farmers of New Jersey, will renew their application to the Legislature at its next session.

It was reported that the following law in relation to advertising the vacant scholarships, was passed by the Legislature:

"A Further Supplement to the act entitled 'An act appropriating scrip for the public lands granted to the State of New Jersey by the act of Congress, July 2d, 1862,'" approved April 4th, 1864.

1. Be it Enacted *by the Senate and General Assembly of the State of New Jersey,* That for the purpose of bringing to public attention the condition of the free State scholarships in the State Agricultural College, the Board of Visitors are hereby authorized to give such notice by letter, or by posting, or by advertisement, of the counties to which the vacant scholarships belong and the mode of filling them, as they may judge to be to the interest of the State.

2. *And be it enacted,* That bills incurred for the above named objects, properly certified by the President and Secretary of the board, shall be audited by the Comptroller, and paid out of the State treasury.

3. *And be it enacted,* That this act shall take effect immediately.

Approved February 10th, 1879.

The board adjourned to attend the reading of the theses of the Senior Class, which were read in the College Chapel, by their authors, as follows:

1. City Well Waters—Condit W. Cutler, Morristown.
2. The Iron Pier at Long Branch—Geo. Hill, New Brunswick.
3. The Adulteration of Vinegar—Franklin Marsh, Rahway.
4. Japanese Bronzes—Tadanari Matsdaira, Tokei, Japan.
5. The Raritan River Improvement—Alfred B. Nelson, Piscatway.
6. Gauging the Raritan River—Francis A. Wilber, Parsippany.

The members of the board could not but express their gratification with the manly and practical character of these papers, and the highly creditable testimony they give that the institution is carrying out the objects of its founders, in thus bringing science to the aid of the arts of industry.

Twenty-two of the State scholarships are now filled, and eighteen are still vacant. Information regarding these scholarships is being circulated, and it is believed that when generally known they will all be filled.

All of which is respectfully submitted.

WILLIAM PARRY,
President.

TRUSTEES' REPORT.

RUTGERS COLLEGE,
NEW BRUNSWICK, December 1st, 1879.

To His Excellency George B. McClellan, Governor of the State of New Jersey:

SIR—In compliance with the act of Congress, approved July 2d, 1862, and the act of the Legislature of New Jersey, approved April 4th, 1864, I beg leave to submit, on behalf of the Trustees of Rutgers College, the fifteenth annual report of Rutgers Scientific School.

I. THE FACULTY.

The Faculty of the Institution remains the same as at the date of the last annual report, except that the number of instructors in the Department of Natural Science has been increased by the appointment of Mr. Francis A. Wilber, of the last graduating class, as Assistant in Analytical Chemistry. The Faculty is now constituted as follows:

Rev. Wm. H. Campbell, D. D., LL. D., President, and Professor of Moral Philosophy.

George H. Cook, Ph. D., LL. D., Vice-President, and Professor of Chemistry, Natural History and Agriculture.

Rev. Theodore S. Doolittle, D. D., Professor of Rhetoric, Logic and Mental Philosophy.

John C. Smock, A. M., Professor of Mining and Metallurgy.

George W. Atherton, A. M., Professor of History, Political Economy and Constitutional Law.

Rev. Carl Meyer, D. D., Professor of French and German.

Francis C. Van Dyck, A. M., Professor of Analytical Chemistry.

Edward A. Bowser, M. S., C. E., Professor of Mathematics and Engineering.

Isaac E. Hasbrouck, A. M., Professor of Mathematics and Graphics.

George B. Merriman, A. M., Professor of Natural Philosphy and Astronomy.

Peter Townsend Austen, Ph. D., F. C. S., Adjunct Professor of Chemistry.

Francis A. Wilber, B. S., Assistant in Analytical Chemistry.

II. COURSES OF STUDY AND DEGREES.

The courses of study in the Scientific School are as follows:

1. *A course of four years in Civil Engineering and Mechanics.*

2. *A course of four years in Chemistry and Agriculture.*

3. *A special course of two years in Chemistry.*

4. *A special course of two years in Agriculture.*

5. *Post-Graduate courses.*

The SPECIAL COURSE in Chemistry is intended for the convenience of students who wish to devote themselves exclusively to that branch of study. Greatly increased facilities have recently been provided for them in the Laboratory and Lecture Rooms, allowing the full employment of their time. On completing the course, they receive a special diploma.

Provision is also made for PARTIAL STUDENTS, who may enter at any time, and elect, under the advice and direction of the Faculty, such studies as they may be found qualified to pursue, with classes already formed. Such students are subject to the general regulations and discipline of the Institution. They are required to have their time fully occupied, and to pass such examinations as may be prescribed in each case. On leaving, they receive certificates stating the studies pursued and the amount of work performed in each.

The two principal courses cover a period of four years each. The studies for the first two years are the same in both courses, and are arranged with special reference to the wants of young men who desire to fit themselves to become land surveyors, or to enter any department of skilled industry, but are unable to remain four years in the Institution. Students who leave at the end of this short course receive certificates.

At the end of the two years' course, students elect whether to pursue the course in Civil Engineering and Mechanics, or that in Chemistry and Agriculture, and for the remaining two years their studies are directed with particular reference to the choice made. Some studies, however, of a general nature, such as History, English Literature, Political Economy, Moral Philosophy and others, are interspersed throughout the entire four years, in order that students may not only acquire a thorough preparation for their special pursuits in life, but may at the same time receive a liberal training which will fit them to discharge wisely and usefully the duties of good citizenship.

Students completing either of the four years' courses, receive the degree of Bachelor of Science.

Heretofore, the degree of Master of Science has been conferred, in course, upon all graduates of three years' standing. The Trustees have long been convinced that the practice of conferring high academical honors, indiscriminately, without regard to the character or attainments of those who receive them, is an unfair discrimination against those who have honorably earned recognition, and calculated to bring all such marks of distinction into undeserved discredit. They have accordingly decided to confer no degrees, "in course," after the Commencement in 1881, and they regard this as an important step in the direction of maintaining a high standard of scholarship.

The degrees of Civil Engineer and Doctor of Philosophy are conferred for distinguished professional or practical success, or, on examination, in prescribed subjects.

A schedule of the several courses of study accompanies this report.

III. POST-GRADUATE STUDIES.

In addition to these courses of study for under-graduates, several post-graduate courses have been arranged (and the number will be increased as occasion requires), for students who desire, after graduation, to pursue special lines of training and research.

In Chemistry, students can pursue special studies and investigations in the Analytical Laboratory, under the direction of a professor, upon subjects connected with industrial or professional life.

In Geology and Natural History, the large collections in Geological Hall are available for extended courses of study, and can be used, under the direction of a professor, for special study in Geology, Mining, Metallurgy, and the various branches of Engineering.

In Agriculture, the well-equipped farm and laboratories give unusual opportunities for advanced studies in this department, and every facility is afforded for their use.

In Mathematics, instruction will be given in any of the following subjects: Geodesy, with practice; Higher Mathematics (pure); Theoretical and Practical Astronomy; the use of Physical Apparatus.

In Modern Languages, the course will include Lectures on French Literature, Lectures on German Literature, Lectures on German Etymology, on German Mythology, and on the Phonology and Morphology of the Indo-Germanic Languages, as bearing on German.

In the Department of Political and Social Science, provision is made for instruction in an advanced course in Political Economy; in the Constitutional History and Jurisprudence of the United States; in the History of the English Constitution; and in the Elements of Roman Law.

These various subjects, according to the choice of students, will be arranged in courses of one, two or three years.

Students completing a full course of two years, in any two of the departments, will be entitled to the degree of Bachelor of Philosophy.

Students completing a full course of three years, in any three of the departments, will be entitled to the degree of Doctor of Philosophy.

IV. TERMS OF ADMISSION.

The conditions of admission to the regular courses of study have recently been somewhat increased, and are now as follows:

Applicants must be sixteen years of age, and of good moral character; and, if they come from other institutions, must bring a certificate of honorable dismission. They are required to pass a satisfactory examination in English Grammar and Spelling, Descriptive Geography, Physical Geography, History of the United States, Arithmetic, including the Metric System, Algebra to Series, and three books of Plane Geometry. In September, 1880, and subsequently, the whole of Plane Geometry will be required.

The regular examinations for admission to the Freshman Class are held on the Friday and Saturday preceding the annual commencement, and on the day before the opening of the fall term. Candidates for advanced standing are examined in the preparatory studies, and in those already pursued by the class which they propose to enter.

V. STUDENTS.

Of the four classes now in the institution, which will be graduated in June, 1880, 1881, 1882 and 1883, respectively, the Senior Class consists of five students, the Junior Class of six, the Sophomore Class of thirteen, and the Freshman Class of nine. There are also eight special students, making a total of forty-two now in attendance.

There have been in the institution, during the year, fifty-two students, of whom one was from Japan, one from the State of Pennsylvania, eight from the State of New York, and the remaining forty-two from the State of New Jersey, representing thirteen counties, as follows:

Cape May,	1	Monmouth,	2
Essex,	3	Morris,	6
Gloucester,	1	Ocean,	1
Hudson,	2	Passaic,	1
Hunterdon,	1	Somerset,	3
Mercer,	2	Union,	1
Middlesex,	18		

Under the law of New Jersey, designating this institution as "The State College for the Benefit of Agriculture and the Mechanic Arts,"

forty students from this State are entitled to free tuition for the entire course. These students are admitted on the recommendation of the Superintendent of Schools in each county, and are distributed among the counties in proportion to their representation in the Legislature, as follows:

Atlantic,	1	Middlesex,	2
Bergen,	1	Monmouth,	2
Burlington,	3	Morris,	2
Camden,	2	Ocean,	1
Cape May,	1	Passaic,	2
Cumberland,	1	Salem,	1
Essex,	6	Somerset,	1
Gloucester,	1	Sussex,	1
Hudson,	6	Union,	2
Hunterdon,	1	Warren,	1
Mercer,	2		

In filling these State scholarships the Trustees have, from the first, adopted the most liberal interpretation of the law; and, in fact, have gone far beyond its requirements, as the following statement, repeated from a former report, will indicate:

"In cases where a scholarship is not filled by the county entitled to it, the Trustees have adopted the policy of allowing it to be filled temporarily, with the consent of the County Superintendent, by an applicant from some other county; and, in general, tuition is habitually remitted to students who are unable to pay that in addition to the other expenses of procuring an education."

The following tables, which have been prepared with great care by Professor Hasbrouck, present, in a condensed form, a complete exhibit of what has been done in the way of furnishing free tuition, since the institution was organized, together with a summary of attendance, by years and by counties:

I.—Table showing the Number of Students Present by Counties, from the Beginning, for each Collegiate Year.

COUNTIES.	Scholarships.	1865–66.	1866–67.	1867–68.	1868–69.	1869–70.	1870–71.	1871–72.	1872–73.	1873–74.	1874–75.	1875–76.	1876–77.	1877–78.	1878–79.	1879–80.
		COLLEGIATE YEARS.														
Atlantic	1	....	....	....	....	....	....	....	1	1	1	1	....	....	....	....
Bergen	1	....	....	....	1	....	2	1	....	....	....	1	1	....	....	....
Burlington	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Camden	2	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....
Cape May	1	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1
Cumberland	1	....	1	1	....	2	2	2	....	....	....	....	....	....	....	....
Essex	6	2	2	3	5	6	6	3	2	1	3	4	2	1	....	3
Gloucester	1	....	....	....	....	....	1	1	1	1	1	....	....	....	....	1
Hudson	6	....	....	....	....	....	1	4	4	3	2	....	....	1	1	2
Hunterdon	1	....	....	....	....	....	....	1	1	1	1	1	1	....	1	1
Mercer	2	....	2	5	2	3	1	1	....	1	1	1	1	....	1	2
Middlesex	2	....	6	13	9	7	9	7	10	14	17	16	17	16	15	15
Monmouth	2	....	2	4	4	4	2	1	....	1	1	1	2	4	4	3
Morris	2	....	1	1	1	3	4	5	3	2	2	1	2	3	4	3
Ocean	1	....	....	....	....	....	....	1	1	1	....	....	....	....	1	1
Passaic	2	....	1	1	1	....	....	....	....	1	1	1	1	....	1	1
Salem	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Somerset	1	1	3	6	6	4	4	5	3	1	....	....	....	1	2	2
Sussex	1	1	1	....	....	....	....	....	....	....	....	1	1	1	....	....
Union	2	1	1	3	2	2	7	8	6	6	6	8	8	4	1	....
Warren	1	....	....	....	....	....	....	....	....	....	....	....	1	1	1	....
Totals, New Jersey	40	5	20	37	31	31	39	40	33	34	34	36	37	32	33	35
Other States	....	2	3	6	7	5	10	14	11	14	14	9	6	7	5	7
Grand totals	....	7	23	43	38	36	49	54	44	48	48	45	43	39	38	42

II.—Table showing the Relation of Students as to Tuition for each Collegiate Year from the Beginning.

COLLEGIATE YEARS.	NEW JERSEY.				Other States.	Grand Total.
	On Scholarship.	Free.	Pay.	Total.		
1865–66	1	2	2	5	2	7
1866–67	8	7	5	20	3	23
1867–68	13	17	7	37	6	43
1868–69	17	10	4	31	7	38
1869–70	15	13	3	31	5	36
1870–71	20	11	8	39	10	49
1871–72	18	15	7	40	14	54
1872–73	17	9	7	33	11	44
1873–74	14	15	5	34	14	48
1874–75	12	13	9	34	14	48
1875–76	15	13	8	36	9	45
1876–77	17	15	5	37	6	43
1877–78	14	12	6	32	7	39
1878–79	20	5	8	33	5	38
1879–80	24	8	3	35	7	42

III.—Table Showing the Number of Students from each County, from the Beginning, and their Relation as to Tuition.

COUNTIES.	Scholarships.	ON SCHOLARSHIPS. By appointment.	By transfer.	Transfer'd to other Counties.	Free.	Pay.	Counted twice.	Total.
Atlantic	1				1			1
Bergen	1	2			2			4
Burlington	3		2					
Camden	2	1	1					1
Cape May	1	1	1					1
Cumberland	1	2		1	1			3
Essex	6	14	4		7	2		23
Gloucester	1	3						3
Hudson	6	4	3		2	2		8
Hunterdon	1	3						3
Mercer	2	5			4		1	8
Middlesex	2	13		7	28	26		67
Monmouth	2	8		1	5	1		14
Morris	2	11		2	2	2	1	14
Ocean	1	3						3
Passaic	2	2			1			3
Salem	1		1					
Somerset	1	5		1	8	3		16
Sussex	1	1			1			2
Union	2	7			7	6		20
Warren	1	1						1
	40	86	12	12	69	42	2	195
Other States								60
Grand Total								255

IV.—Table Showing the Number of Students from each County at the present time, and their Relation as to Tuition.

COUNTIES.	Scholarships.	ON SCHOLARSHIPS. By appointment.	By transfer.	Transfer'd to other Counties.	Free.	Pay.	Total.
Atlantic	1						
Bergen	1						
Burlington	3		2				
Camden	2		1				
Cape May	1	1					1
Cumberland	1						
Essex	6	2	2		1		3
Gloucester	1	1					1
Hudson	6	1	2			1	2
Hunterdon	1	1					1
Mercer	2	2					2
Middlesex	2	6		4	7	2	15
Monmouth	2	3		1			3
Morris	2	3		1			3
Ocean	1	1					1
Passaic	2	1					1
Salem	1						
Somerset	1	2		1			2
Sussex	1						
Union	2						
Warren	1						
Totals, New Jersey	40	24	7	7	8	3	35
Other States							7
Grand Total							42

V.—Table showing the Occupation of 87 *of the Students of Rutgers Scientific School who have Graduated, and of* 50 *who have left without Graduating, from the beginning to September,* 1879, *inclusive, these being the only ones whose occupation is certainly known.*

STUDENTS.	OCCUPATIONS.							
	Eng'r.	Arch't.	Mf'r.	F'mer.	M. D.	Law'r.	T'ch'r.	Busn's
Who graduated	38	4	10	6	6	8	8	7
Per cent	43.5	4.6	11.5	6.9	6.9	9.2	9.2	8
Who did not graduate	5	2	6	7	4	3	4	19
Per cent	10	4	12	14	8	6	8	38
Totals	43	6	16	13	10	11	12	26
Per cent	31.4	4.3	11.7	25	7.3	8	8.8	19

VI. SPECIAL DEPARTMENTS.

The method and scope of work in the several departments of the institution have undergone no particular change since the date of the last report, though it is but just to the gentlemen in charge to say that there are in each department gratifying indications of steady and vigorous growth.

1. THE MATHEMATICAL COURSE.

In this course, students, during the first two years, are occupied with Algebra, Geometry, Trigonometry, Descriptive Geometry, Surveying, Railroad Curves, &c., and have sufficient field practice to make them familiar with the use of surveyors' instruments, and able to survey farms. Those who take the engineering course for the full term of four years are instructed in Analytic Geometry, Calculus, Mechanics, Civil Engineering, Geodesy, &c., having, at the same time, daily practice in Draughting. The aim of the instruction is to make good draughtsmen, and to give the student a clear idea of the elements of the higher mathematics and a knowledge of the theory of engineering, so that, after graduation, he may be able to pursue, understandingly and continuously, an advanced course of mathematical study, or to go into the field or the office as an engineer's assistant, and do good, reliable work. For five years past, some of the students in this department have been employed on the geodetic survey of New Jersey, with very satisfactory results. The training in Geodesy which they previously received in the class-room made them worth far more for practical work than those who enter the field without such instruction. This course does not aim to make practical engineers, but to lay the foundation on which alone practical success can be assured.

The variation of the magnetic needle at Rutgers College was determined this fall by the mathematical division of the Junior Scientific

Class. An observation was taken on Polaris at its greatest eastern elongation, on the evening of October 4th, and the line of sight marked on the ground. With the polar distance of Polaris equal to 1° 19′ 50″, and the latitutde of the place equal to 40° 29′ 52″, the azimuth of Polaris was computed to be 1° 44′ 59″. The magnetic bearing of the line of sight to Polaris was observed on several days at about three o'clock P. M. and found to be 9°. This bearing of 9°, diminished by the azimuth of 1° 44′ 59″, gives 7° 15′ for the variation of the magnetic needle, at the present time, (November, 1879,) at Rutgers College.

2. GRAPHICS.

The methods of instruction followed in this department are, in general, the same as those described in previous reports, to which reference is made. The results obtained have continued to be satisfactory, and,we believe, beneficial to the student.

In addition to the customary class of problems in Geometrical Construction, some time was devoted, during the past year, to the graphical solution of so-called Algebraic Problems. The novelty of the methods, the directness of the solutions, and the perspicuity of the results in their relations to the conditions of the problem, have proved a source of interest and instruction to the students, who became quite expert is this method of solution. As a means of preliminary investigation, when general results only are required, this method has great great advantages; while in many cases the accuracy of its conclusions are unquestionable. In complicated problems the mind often finds the eye a valuable auxiliary, and drawing—the language of theeye—explains the way out of difficulties and greatly facilitates the attainment of desired solutions.

In connection with the methods of the solution of problems in Descriptive Geometry, as described in the last annual report, a new feature has been introduced. Many colleges "have secured, at great expense," sets of Ollivier's or of Shroeder's models in Descriptive Geometry. We have always looked with some distrust upon these models as adjuncts in teaching the subject, because the student is apt to rely upon them to explain, by illustration, relations and results which should be recognized by abstract reasoning—by analysis; and thus one important benefit of the study is lost. Not as a compromise between the two methods, but to secure a better understanding of the magnitude or relations discussed, by reproducing them from the principles or definitions involved, the students in Descriptive Geometry were required to construct models of some of the surfaces treated. Besides thus making their knowledge more accurate by testing it, they acquired some familiarity with another very important aid to the worker in technical science—the model, and with its construction and uses.

Many of the drawings made during the year merited commendation. Some of the work in topographical representations approached very closely in neatness of execution the deservedly famed work done at the United States Coast Survey office, greater praise than which is scarcely possible. Several of the drawings in shades and shadows, linear and aerial perspective and construction, and of those by the graduating class to accompany their Theses, show a neatness of execution and comprehension of the adaptability and best arrangement of figures for the purpose of illustration, which are among a student's most useful acquisitions.

Written language, in its present development, is but a species of drawing. It was simple drawing at first, before it differentiated the sounds of words and letters and, later, their specific and individual representatives. In the days of the Pharaohs there were records as well as now. Then the idea of *Sun* or *Eagle* might be conveyed by a drawing, while now we indicate the same idea by a different combination of lines; but by a drawing still, when these lines take the form "Sun," "Eagle." Though the method of hieroglyphics be called a primitive form of writing, it was quite sufficient and quite effective; and to-day, in many cases, ideas can be indicated with greater precision and clearness by drawings—modern hieroglyphics—than by our new word-drawing. This fact is especially prominent in the practice of the United States Patent Office, where a drawing, or a model, is required whenever possible. And quite naturally. An idea is conveyed through a figure-drawing by one less mental operation, and this frequently a trying one, than when presented in a word-drawing, besides being expressed much more concisely and without ambiguity. It is not surprising, then, that the architect indicates to the workman the style of building he would have erected, the decorations of its interior, or even the patterns of its carpets and the designs of its upholstery, by drawings rather than by words; that the inventor indicates his invention; the mechanical engineer the form and relations of the parts of a machine; the civil engineer the details of his bridge; the landscape gardener the arrangement of his paths and drives, and the farmer the position and direction of the drains on his land by the methods of *graphics*.

The intimate relations of drawing to the material prosperity of a community may be seen when we remember that almost everything to be well-made must be made from drawings. To this, reference, with examples, has already been made. If the necessity for a knowledge of drawing is so constant and general, some provision should be made to supply it, for not only must we have skill to make the drawings, but skill also to interpret them when made. The workman who can thus interpret a drawing, who can see in it, complete before him, the object he is expected to produce, who can reproduce the drawing, if need be, can work more rapidly, more accurately, with less superin-

tendence, and therefore, with more profit to himself and to his employer, than he could without this ability. All industries have demonstrated that an ignorant workman is, within limits, costly in proportion as he is ignorant. The employer cannot afford to fill his shops with inferior workmen when he can obtain better, for the labor of the latter is more profitable, both in the price obtained for the product and the promptness with which it is sold, and, therefore, the capital reinvested in the production of other articles. The employee cannot afford to be less skilled than possible in his trade, for his expenses are the same, in either case, and his wages will be increased in the latter. In short, the industries of to-day require *artisans* as well as *artists*.

Again, the large number of children who will quite certainly enter some industry where drawing is an important factor, is an argument for their education in this subject. It is estimated that in Massachusetts three-fourths of the children in attendance upon the public schools are of this class. The number in this State must also be large.

That drawing lies at the foundation of all technical education has been widely and practically acknowledged. Previous to 1851 the workshops of England produced substantial and cheap wares, yet they were unable to compete with their rivals on the continent in the markets of the world. The World's Fair of that year, at London, made manifest, not only this superiority, but its secret, if secret it were. The English government immediately founded the South Kensington Art School, with liberal pecuniary support, and with instruction in drawing as its foundation. In ten years the increase in the *value* of the exports had far exceeded that of their *amount*, and political economists assented to the general verdict which gave the credit for this increased prosperity to the art school. It then became the turn of France to consider the interests of her industries, now suffering under the competition made active and successful by influences emanating from the new English art school. A commission appointed in 1863 for this purpose recognized the importance of drawing in promoting and making efficient the industries of a people—in fact, regarded it as the essential requisite to industrial success—saying: "Drawing, in all its forms, has been unanimously regarded as the one [branch of instruction] it is most important to make common." Again in 1876 the French Commission on the Educational System of the United States, in their report said, referring to drawing, "France ought to reinvigorate her productive powers at the very source of art." The little State of Wurtemburg, with a population not larger than that of New York city and suburbs, has one of the most noted polytechnic schools in Europe, and a recently erected large scientific school, in both of which drawing is one of the principal studies, besides four hundred and fifty schools especially devoted to this subject.

Massachusetts has incorporated the element of drawing so fully in

her educational system that the Committee on Drawing is the most important in the school boards of the State. It is now obligatory on each city of five thousand inhabitants in that State to provide instruction in this branch.

That England, with whom commercial supremacy is almost the supreme good; France, which has been called "The first in taste, the first in design, and the first in skilled workmanship;" Wurtemburg, with all the fatherly care of its subjects which marks the German State, and Massachusetts, whose success in advancing her material interests is widely recognized, should all unite in regarding drawing as the central subject in industrial education, and should have achieved so much success under this position, gives assurance that this art is not merely ornamental, but eminently economical.

And in part economical *because* ornamental. The relations of æsthetics to political economy have not had the recognition which they deserve. Tasteful and elegant designs are required by the increasing culture of the new world. Not only does drawing respond to this demand, but it stimulates it in turn, for every beautiful creation of the draughtsman's imagination is an educator more powerful because a thing of beauty. Not only is the artist who makes an original design for a mansion, a monument or a machine, an article of jewelry or of house decoration, a producer, but if this design is for an object of beauty as well as of special adaptation to its purpose, it has an enhanced value. It is useless to say that "a thing of beauty" may attract the eye, give pleasurable emotions, evoke exclamations of delight or of praise, but can have no effect upon the ledger balance, the true test of whether a quality or quantity has merits. People still buy, not only what they need for their wants, but of different objects suited to their wants they select those most pleasing to the eye. We constantly import certain classes of goods, even though our own manufacturers produce them at a less price, because the foreign article has been made from carefully prepared designs by artisans competent to make as well as to interpret these designs; and our people, admiring beauty, are willing to pay an increased price for an article in the manufacture of which taste was exercised and elegance of form and decoration secured.

The value of an article, then, depends not merely upon the cost of the raw material and of the labor bestowed upon it, but also upon the taste and skill employed in its designing and manufacture. The price labels attached to the articles exposed for sale in large bazaars give this evidence. If beauty has a commercial value, those means which enable the workman to know how and where to surround and permeate his work with this valuable quality have a claim to recognition even by modern Gradgrinds. And the artist must be regarded as a producer as well as the miner, the farmer, or the mechanic, and drawing is as real a factor in the material prosperity as agriculture.

Few States are more interested than New Jersey in technical science; so are few more dependent than she for the success of their industries upon principles and methods taught and skill acquired in the draughting-room. The large manufacturers of paper hangings and textiles must have new patterns for their fabrics; the manufacturers of jewelry, pottery and fine glassware require the pencil of the designer for the traceries which decorate their productions; the manufacturer of agricultural implements cannot make even a plow "by guess;" how much less can a builder of locomotives place upon the iron track a perfect engine, fitted for its work, without having first given the founder, the blacksmith and the planer the drawings after which they are to fashion the several parts; while, for the increasing demands and emergencies in these and other industries, new machines must be constructed from drawings which crystallize out of these wants and the principles of mechanics the means of meeting the wants. Jersey City, Trenton, Newark, New Brunswick, Paterson and other manufacturing centres make constant call upon the draughtsman's skill for their various productive industries.

According to the last United States census the capital employed in New Jersey, in manufacturing industries, was nearly $80,000,000, and the value of the products nearly $170,000,000. Allowing to each dollar of product an increase of only five cents—which experience shows to be much too little—by reason of the increased value imparted by increased taste and skill in artist and artisan, the total increase would be more than ten per cent. on the capital invested, without increase of expense. Here is a margin which the capitalist could well afford to share with his workmen. Does not this suggest to employers the desirableness of encouraging art education? and does it not show to the employed a better method for securing an increase of wages than the strike—much more certain, much less disagreeable?

Conscious of these needs of our State, we are striving to meet them from the means placed at our disposal. But our students are preparing for various and dissimilar vocations. Training in special courses in drawing to any great extent is therefore nearly impossible. The knowledge of the details of drawing needed by an engineer, a physician, a farmer or a designer of patterns is quite unlike in the several cases, yet a certain facility with the pencil or drawing-pen is a quite essential part of the professional equipment of each. Readiness and accuracy in expressing ideas and facts by drawing must be of great assistance, whatever calling the student may follow. This power of representing—the patent result of this course—is neither the only one nor the most important. While acquiring this power the student has also acquired a training of the eye, of the hand and of the mind, to quickness of perception, deftness of execution and promptness in the recognition and resolution of relations and conditions which could be

obtained from few other exercises. To these ends is the course in Graphics specially directed.

3. PHYSICS AND ASTRONOMY.

Instruction is given in Mechanics, Sound and Light four times a week during the first two terms of the Junior Year. "Deschanel's Natural Philosophy" is used as a text-book, but is largely supplemented with lectures, explanations and problems. The subjects are treated both experimentally and theoretically. The students are required to take notes of the lectures and experiments, and of the solution of exercises, and these notes are at intervals inspected by the instructor.

The Mechanics included in the first part of this course serves not only as a good preparation for the subsequent parts of General Physics, but also as an introduction to Analytical and Applied Mechanics in the Engineering Course.

It is aimed to make the principles clearly understood, both in their nature and their application, by the following methods:

1. By experimental illustrations.
2. By their use in the explanation of these illustrations, or of well-known phenomena.
3. By their application to the solution of numerous exercises of a practical character.

Quite an extensive supply of physical apparatus, to which recent additions have been made, permit a large variety of illustrative experiments. It is not the sole or chief aim in teaching this science to store the mind with facts, but rather to develop the reasoning powers and accustom the student to trace the connection between cause and effect. After grasping a general principle established by observation and experiment, he is exercised in deducing from this general law the numerous and varied consequences which, under stated conditions, flow from it.

Where a student wishes to pursue further a special subject by experimental investigation under the direction of the instructor, opportunity is given as far as present means allow, and sometimes, with a little ingenuity in the adaptation or construction of simple apparatus, valuable results are obtained.

When desired by a sufficient number of students intending to teach Physics in public or private schools, a brief course of lectures will be given in the spring term on the methods of teaching, with special reference to such easy experiments and illustrations as may be given with apparatus which can be constructed or obtained at a very small expense. During the first two terms of the Senior Year, the subjects of Heat and Electricity occupy two hours per week. Deschanel's book is used as a basis, and all necessary amplifications are introduced into the lectures both from more extensive works and the current literature of the day.

The application of the Science of Heat to the warming and ventilation of houses, to the steam engine and to the weather, is made by such illustrations as will tend to fix principles, as well as facts, permanently in the memory. The subject of Electricity is treated with equal fullness of detail.

Throughout the whole course of Physics care is taken to show the intimate connection of the various branches of science, and to give to the novelties of the day no more than a just share of attention. The concluding part of the course is devoted to such suggestions and directions as are judged to be calculated to stimulate to and guide in original work.

Ample facilities are afforded for the study of Theoretical and Practical Astronomy. The Daniel S. Schanck Observatory is a two-story building, with revolving dome, constructed especially for astronomical work. It contains in the main part the Equatorial Telescope, mounted on a pier of masonry extending several feet below the surface of the ground, and detached from the floors, through which it rises, so as to be unaffected by the tremors of the building. The telescope eight feet four inches in focal length, and the object glass, six and one-half inches in diameter, was made by the late Henry Fitz, of New York. It has a small telescope attached for a finder, a driving clock, a position micrometer; a number of eye-pieces, positive and negative, with one diagonal, and colored glasses for observing the sun. The declination circle is ten inches in diameter, reading by verniers to one minute of arc, and the hour circle, seven and one-half inches in diameter, reads by verniers to six seconds of time.

On the west side of the main part is an extension for transit observations. The Meridian Circle used for this work has a glass four inches in diameter and four feet ten inches in focal length, with circles seventeen inches in diameter reading by two microscopes to single seconds of arc. The diaphragm carries one horizontal and nine vertical wires. There are also the usual accompaniments of spirit-level and reversing apparatus. The building and all the instruments were donated by friends of the College.

The Observatory has also a Sidereal Clock, by Wm. Bond & Son, the gift of John Clark, Esq., of New Brunswick, with an electrical break circuit; a Mean Time Clock, by Howard & Co., the gift of the Peithessophian Society of Rutgers College; and a Reflecting Circle, by Stackpole & Brother, the gift of the Philoclian Society of the College.

By the generosity of a friend of the College some necessary repairs have been recently made to the sidereal clock, and the break circuit work improved, involving a considerable expense.

By the courtesy of Prof. Hilgard, Superintendent of the United States Coast Survey, the Observatory has also the use of a Kipp Chronograph, which records the seconds of the sidereal clock. Connection by telegraph wire has recently been made with the Western Union Telegraph Com-

pany's line, and a series of observations in connection with the United States Naval Observatory at Washington is now in progress, for the determination of the longitude of the Observatory. As a part of this work an exchange of time signals is made, the clock at Washington recording its seconds along with those of our clock on the chronograph at this Observatory, and our clock sending its seconds, automatically, to be recorded at the Washington Observatory. This gives a very exact determination of the difference in time between the two clocks, and also of the difference in longitude between the two observatories, when the errors of the clocks are ascertained.

Acknowledgments are due to the Western Union Telegraph Company, for the gratuitous use of their line, and for other favors, and also to the Superintendent of the United States Naval Observatory, for the loan of a Personal Equation apparatus, as well as for courteous co-operation in the work of ascertaining longitude.

The Elements of Astronomy are taught by the use of a text-book and by lectures four times a week, during the last term of the Junior Year. Those who elect a special course in Astronomy in the Senior Year learn the use of the instruments at the Observatory and take part in the observations. A class is now pursuing this course and doing excellent work. Among the subjects included in the course are the following:

Theory and use of the Instruments.
Determination of Instrumental Errors.
Transformation of different Systems of Co-ordinates.
Determination of Sidereal, Apparent and Mean Solar Time.
Reduction of Observations for Refraction and Parallax.
Determination of Latitude and Longitude.
Deduction of Stars from apparent to mean Place, and *vice versa*.
Theory of Interpolation.
Combination of Observations by the Method of Least Squares.
Calculation and Projection of Eclipses.
Calculation of Ephemerides.
Calculation of the Orbits of Comets and Planets.

4. CHEMISTRY.

Chemistry is taught with increased fullness every year. Eighteen hours per week are devoted to this branch of science, and ample time thereby given to the student to digest and assimilate each subject, presented in successive portions. Variety of occupation is also thus secured, with its well-known advantages.

It is believed, as the result of careful inquiry, that no other institution, except professedly special schools, devotes so much time to instruction in Chemical Science.

Students in all the courses of the school have four terms of lectures

in the various branches of Chemistry, and are required to take full notes, in order to train them in habits of accurate observation and facility of expression. These notes are taken in pencil, and are afterwards copied out in ink and handed in to the Professor for examination, criticism and correction.

During the first term, devoted to Inorganic Chemistry, the theory is presented, the construction of formulæ taught, and the chemical relations of air and water experimentally shown. The rudiments of the philosophy of gases are impressed upon the students by abundant illustrations. Especial care is taken, at this early stage of progress, to make all experiments demonstrative, so that pupils may learn to discriminate between mere hypothesis and theory based upon facts. The most approved forms of apparatus are used, when best suited to elucidate the subject, but in many cases familiar utensils are employed, for the sake of associating with them in the mind the principles learned, which will be likely to come more frequently to the recollection than would be the case if both principles and apparatus were strange.

The second term is chiefly occupied in considering the non-metallic elements, both theoretically and practically.

The chemical relations of the business world are brought to view in connection with the principal acids, and the prominent peculiarities of the various branches of manufacture are pointed out.

The third term is devoted to the metals. Mining, metallurgy and the industrial applications of metals and their alloys are fully described with the aid of sets of specimens and illustrative operations on a small scale.

Organic Chemistry is taught by lectures and experiments. The ground covered by this branch is so extensive that only a beginning can be made in its study. The more important series of compounds, however, are studied, and particular attention is given to the practical relations of the science to food, beverages, medicines, coloring and dyeing, and soap making; to Animal and Vegetable Physiology, and to Agriculture. The principles here learned find their uses in the after-work of the students in the analytical laboratory, in business, and in the professions.

Three rooms in the Geological Hall are at present devoted to chemical analysis. These, with the annexed balance-room and store-rooms, and the general lecture-room, occupy the first floor of the building.

Mention was made, in the report for 1878, of an important addition having been made to the working facilities of the department by devoting a separate room and special tables to Blowpipe Analysis. This study has, since then, been greatly developed. New desks of the latest and most approved form have been built to accommodate the continually increasing number of students. The course has been extended to the full limits of Qualitative Blowpipe Analysis, the students being able to analyze very complicated substances. An extensive stock of apparatus is kept on hand in the supply-room, so that the student is able to use the most modern appliances in his analyses.

In beginning the study of Blowpipe Analysis, the student is first taught how to blow glass, and make much of his own apparatus. He is then made familiar with the properties of the various chemical elements by performing their characteristic tests, as laid down in the text-book. Having become acquainted with the properties of the elements, he proceeds to analyze substances, or, in other words, to apply for the detection of the elements, the characteristic tests he has learned. In this manner he soon becomes expert at detecting even traces of the metals, &c. The small size of the apparatus, and the ease with which analyses are performed by its aid, make it an instrument of great value to the professional man, whether he be a mining engineer desirous of examining an ore in a part of the country where only a candle is obtainable, or a physician wishing to detect, in a few minutes, the presence of arsenic, mercury, or various other metallic poisons in a suspected substance.

In all cases the student works with his note-book at his side, and must note down his work as he proceeds. The analyses are reported immediately after their completion, in printed forms, and filed for reference. The aim of these reports is manifold. Students are compelled to write down a clear and concise account of their experiments; and to be able to keep an accurate written record of their work is alone an important thing. They learn to describe natural phenomena in explicit notes—a very useful, and, for the scientific man, an absolutely indispensable acquirement. In reporting, they rigidly preserve the three great divisions of experimental science, *Experiment*, *Observation* and *Inference*. They thus become perfectly at home in practical logical deduction. Their minds are developed by their continual use of practical logical demonstration, in a way that only actual familiarity with experimental work can effect. The continual striving to express their ideas in a concise and logical form inculcates a thorough idea of system and business habits.

Determinative Mineralogy has been made a special branch of instruction, and is taken up after completion of Blowpipe Analysis. By the aid of the blowpipe and a few chemicals, the student is soon able to determine the nature of any mineral or ore.

The examinations in Blowpipe Analysis having been successfully passed, and the student having shown, by an actual analysis of a test substance, that he is a capable analyst, the study of Qualitative Analysis is entered upon. Here a far more complicated set of apparatus and chemicals is needed. While Blowpipe Analysis can detect only a limited number of substances, Qualitative Analysis includes all the elements. The student begins in the same manner as with the blowpipe. He performs the characteristic tests, and learns the manipulations. He soon enters upon actual analysis. From the most simple substances he proceeds gradually to more difficult ones, until his analyses include the most complicated and difficult mixtures. Accompanying the practical work in the Laboratory, full courses of

lectures are delivered on the subject, by which the student is given a clear idea of the theory of the subject. The course concludes with examinations in the theory and practice of analysis.

Quantitative Analysis now begins. While in his former studies the student has learned how to detect the constituents of a substance, he now learns how to determine their *amount.* Here he acquires the delicacy and accuracy of the quantitative method, in which the slightest speck of matter represents a certain weight, and becomes familiar with the handling of costly instruments of precision. The course includes the analysis of minerals, ores, coals, metals, waters, fertilizers, wines, urine, poisons, &c.

In addition to the above subjects, a course in microscopical investigation will soon be added. A room is also being fitted up for a thorough course in practical assaying of ores, or fire analysis. In the Blowpipe, Qualitative and Quantitative Laboratories, improvements and extensions are constantly being introduced, which, with the increasing stock of apparatus and chemicals, will soon make them unsurpassed in thoroughness.

In the practical study of Analysis the student is able to apply and carry out the theoretical principles of Chemistry which he has learned in his lectures on General Chemistry. The continual practice in detecting substances by their characteristic appearances under varying conditions, and the necessity in every case of rigid experimental proof, become habits applicable to all things in actual life, and give the student a drilling and foundation in practical logical deduction and induction that are of incalculable value to him.

The student concludes his course in the Laboratory by undertaking an original experimental investigation on some point connected with theoretical or applied Chemistry. He now leaves the firm ground of known facts and methods and enters on the limitless fields of investigation and discovery. It is here that his enthusiasm is fully aroused, and his determination and energy display themselves. He discovers new facts, handles new substances, invents methods, originates expedients and learns the value and power of discovery. Failures only incite him to effort. Perseverance and determination to succeed become habitual to him.

It is in this field that the most strenuous efforts are being made toward development, for it is by this advanced teaching alone, that the student can be made to think and act for himself, place confidence in his own powers and raise himself by *original* thought and work in the profession he adopts.

The Professors in charge allow a free reference to their own books, and the College Library is open daily for consultation. The fundamental idea of the plan of instruction is to make the students independent, by teaching them not only what a routine analyst ought to know, but also the proper use of the books upon the subject. Inas-

much as many students in the regular course intend to pursue Medicine, Agriculture, &c., and hence will not be likely to make analyzing a business for themselves, they are taught also to know when and how to have analyses made, and shown how the habits of exactness and system acquired in a Laboratory are important elements of mental training.

Special students in Chemistry are, of course, required to spend much more time at work, in order to acquire greater facility. Lectures are delivered on the general theory of Quantitative Analysis, which explain minutely the method in use. The students are required to hand in once a week a written method, with references to the text-book, for the analysis of supposed mixtures. These papers are criticised and discussed by the Professor. In this way the student gains a really exact and practical knowledge of the whole subject, and is never at a loss for a method in the analysis of a substance with which he has not had previous analytical experience. We have good reason to believe that anyone, on leaving the Laboratory after a full course, is competent to devote himself with success to any line of business connected with Chemistry, without further need of instruction. Certain it is that medical students invariably say that their course at College has proved invaluable to them. By degrees it is becoming more evident to the public that a rapid and thorough development of the industrial resources of our country demand not only a trained class of original workers, but a spread of scientific information among the masses, in order that opportunities for employing specialists to advantage may not pass unobserved.

Practical chemists must necessarily spend most of their time in the Laboratory. The farmers and men engaged in industrial pursuits generally, ought to know what chemists can do, and ought to be able to judge pretty nearly when a chemist's aid is advantageous. The aim, then, is to teach analysis, both as a means of educational and mental discipline and as a profession.

There are now thirty-six students engaged in Chemical Analysis, of whom eight are special students.

5. THE MUSEUM.

The Museum of the College occupies the second and third stories of Geological Hall, consisting of one large room, with galleries and store-rooms at the south end. The main room is ninety by forty and twenty-five feet high. Large windows on both sides and at the north end give an abundance of light, and so distribute it that everything is exhibited to the best advantage. On each side, under the galleries, there are seven double cases, so placed as to make an alcove at each window. These are sufficiently large to admit narrow, open cases in front of each window, whenever additional space for the exhibition of specimens is demanded. These side cases contain drawers below and

shelves above. The former serve for the storage of duplicates, the latter hold those on exhibition. The cases on the east side are devoted to Mineralogy and Metallurgy. Of these, one is filled with a complete collection of minerals for the use of students of Mineralogy. They furnish material for the use in blowpipe analysis, for the ordinary chemical examinations, and for the illustration of the general principles of mineralogy, as crystallization, &c. Here are small suites showing degrees of hardness, electrical characters, magnetic properties, cleavage, &c. Three of the side cases are filled with larger and better examples of minerals, arranged according to the system of Dana. These can be studied, under special arrangements, by more advanced students. The collection is good and equal to the wants of elementary instruction, and for post-graduates to an advanced position. Three cases are filled with ores of the various metals—one containing iron ores, a second those of zinc (including handsome specimens from the celebrated mines of Sterling Hill and Franklin Furnace), and the third with native gold and silver, and ores of copper, lead, nickel, antimony and other metals. Among the copper compounds there is a very fine collection from the mines of Chili, South America, the gift of Miss Evans, of New Brunswick.

The west side cases hold a part of the Paleontological and Geological collections, grouped according to their age. One case contains specimens which illustrate the formation and structure of rocks. These occupy the shelves and are always to be seen by the student of Geology. Below them is a suite of five hundred specimens from Dr. Krantz, of Bonn, also for students' use. They represent by typical examples all the geological ages and periods and give a general notion of the succession of the formations of the earth. In the remaining cases the characteristic rocks and fossils of the Silurian, Devonian, Carboniferous, Triassic, Cretaceous and Tertiary and Recent ages are so arranged that the various changes in the condition of the earth and its animal and vegetable life, are traced from the eozoon of the Archaic rocks to the frail shells that are to-day filling up our lakes and marshes with shell marl.

On the main floor there are five cases of ores, minerals and rocks; and two cases containing the collections of recent birds and animals.

Two of the cases contain typical specimens of the rocks, ores, marls, clays, sands and other native minerals of New Jersey, which are used in manufactures and agriculture. This collection is largely a duplicate of that exhibited by the Geological Survey at the Centennial Exposition at Philadelphia. It presents to the view of the student the varied natural resources of a State.

Two cases are filled with the Beck cabinet of minerals. In these new cases this unique and valuable collection shows to advantage, and in an appropriate and peculiar manner testifies to the diligence of Dr. Beck as a collector and mineralogist. Aside from its intrinsic import-

ance, it will serve to call up pleasant recollections of this distinguished scientist, so long connected with the College.

A pyramidal case in the centre of the room exhibits a showy lot of quartz crystals and associated minerals from Ellenville, Ulster county, New York. The larger part of them were in the original Lange collection, which was bequeathed to the college a few years ago.

For illustrating iron working, two collections are particularly noticeable. One of these is a set of T-irons from the Trenton Iron Company; the other a similar one of T-irons, and of rails, from the Union Iron Company, of Buffalo, New York. Many other Metallurgical specimens in iron, zinc, copper, lead, nickel, silver, and gold, show how these metals are obtained from their ores, and form a valuable nucleus for a Metallurgical cabinet.

The few specimens of recent birds and animals occupy two large cases. This very important department is in need of large additions.

The conchological collection has been classified and beautifully arranged by George W. Tryon, of Philadelphia, in a series of flat cases running around the sides of the gallery. The collection is large, and equal to the needs of the most advanced collegiate course. It is well filled with the most characteristic species and genera of living mollusks.

The most conspicuous object in the Museum is the skeleton of the whale which was caught in the Raritan river four years ago. The skeleton is suspended in the centre of the room, near the level of the gallery floor. It illustrates on a large scale, to the student of anatomy, the mammalian skeleton, and becomes a type in a series of such forms.

A human skeleton serves for the study of human anatomy.

The Indian antiquities and other ethnological material have been arranged in one of the cases of the main floor. The collection is small, but contains valuable relics, and shows the character of the remains of our aboriginal population.

A collection of the native woods of New Jersey has recently been placed in a new case in the south gallery. It numbers about one hundred pieces, and exhibits nearly all of the more common woods found growing in our State. Some additional specimens are still much needed to make it full and representative.

The more recent additions to the Museum are:

1. A mastodon tusk, four feet long, which was found in the gravel formation at Trenton, New Jersey. It was presented to the College by E. F. Brooks, C. E., of the Class of 1872.

2. A large suite of rocks illustrative of the geological formations of the Department of Puy de Dome, France.

3. A collection of flint implements and associated fossil remains from the celebrated fluviatile beds at Amiens, France.

4. Graphite and mica from Buckingham, near Ottawa, Canada, from Jacob Weart, Esq., of Jersey City.

5. A suite of rocks and fossils from the Paris basin.

6. Native gold from the mines, Nova Scotia. From George Edward Stubbs, of the Class of 1878.

7. Coal and vegetable impressions from the red sandstone, Belleville, New Jersey. From Alfred Ford Skinner, of the Freshman Class in College.

The glass cases of the Museum are inadequate to the proper display of materials in store, and additional floor cases are wanted to fill up the main room, besides smaller cases for the galleries in which to place zoölogical and botanical specimens.

These statements indicate an increase in the attractive objects of the collection, as well as in the valuable specimens for aid in object teaching; but the wants of the Museum are still large, since no collection is too full for the complete survey of any department of natural history, although quite adequate to the more limited requirements of the ordinary College student: but for a Scientific School and for specialists it cannot outgrow their needs.

The Museum is open every afternoon when the College is in session.

6. THESES.

The following abstracts of a portion of the theses read before the State Board of Visitors by members of the graduating class, are thought likely to be of interest, both on acount of their subject matter and as specimens of the work done by our students:

AN EXAMINATION OF VINEGARS. BY FRANKLIN MARSH, B. S., '79.

(Course in Chemistry.)

After giving the history of vinegar, and describing in detail its preparation from alcohol, brandy, cider, beer, beet roots, &c., Mr. Marsh writes as follows:

Adulterations.—The principal foreign substances with which vinegar is adulterated are sulphuric, sulphurous, hydrochloric, nitric, tartaric and oxalic acids. In certain cases lead and copper have been found in vinegars that have stood in vessels made of those metals. In England the strongest kind of malt vinegar manufactured is termed "proof vinegar," and contains five per cent. of acetic acid. It almost always contains a certain amount of sulphuric acid, for the law allows the manufacturers to add the one-thousandth part of this acid, this addition being supposed to make the vinegar keep better. A properly made vinegar, however, does not need to be thus protected.

The most common and most dangerous adulterant of vinegar is sulphuric acid. During the past month I have examined fifty samples of vinegars bought in the stores of New Brunswick and Rahway. Forty-two of the samples I purchased in New Brunswick. I ex-

amined the lot for sulphuric acid, and I will state that in only one did I find more than a minute trace of sulphates, and in none could I detect any free sulphuric acid.

The samples were first tested with a solution of barium chloride, which gives a white precipitate with sulphuric acid and sulphates. As a test for free sulphuric acid, the vinegar was evaporated to dryness with some cane sugar. If free sulphuric acid is present the mass becomes black, owing to the charring of the sugar by the acid.

I also determined the specific gravity by the hydrometer, and found that they varied from 1.0075 to 1.03; those of the lowest specific gravity coming from the cheaper and smaller grocery stores, as a general thing. In color they varied from colorless to dark brown, some being clear, others murky and thick.

From my examination I can state that the vinegars sold in New Brunswick are chiefly cider vinegars, and are free from sulphuric acid or other dangerous adulterants.

Here follows his table of examinations:

Tabular Results of an Examination of Vinegars, showing Specific Gravity, with the Traces of Sulphates, Chlorides and Nitrates of each Sample of Vinegar.

Sample.	Specific Gravity.	Sulphates.	Chlorides.	Nitrates.	Sample.	Specific Gravity.	Sulphates.	Chlorides.	Nitrates.
No. 1	1.015	....	....	No trace in any sample.	No. 26	1.0125	....	....	No trace in any sample.
2	1.0075	....	....		27	1.02	....	....	
3	1.01	....	trace		28	1.02	....	....	
4	1.015	....	....		29	1.0225	....	....	
5	1.01	....	trace		30	1.0175	....	trace	
6	1.0075	trace	....		31	1.02	....	....	
7	1.0125	....	trace		32	1.0125	....	....	
8	1.0175	....	....		33	1.0175	....	....	
9	1.0125	....	....		34	1.02	....	....	
10	1.015	....	....		35	1.0075	....	trace	
11	1.01	....	trace		36	1.0125	....	....	
12	1.015	....	....		37	1.02	....	....	
13	1.015	....	....		38	1.015	....	....	
14	1.0175	....	....		39	1.01	....	....	
15	1.0125	....	....		40	1.02	....	....	
16	1.01	....	....		41	1.01	....	trace	
17	1.03	....	trace		42	1.01	....	....	
18	1.02	....	trace		43	1.015	....	....	
19	1.0225	....	....		44	1.0125	....	trace	
20	1.005	....	....		45	1.02	....	....	
21	1.0075	....	....		46	1.015	....	trace	
22	1.0175	....	....		47	1.01	....	....	
23	1.0125	....	....		48	1.01	....	....	
24	1.0125	....	....		49	1.015	....	trace	
25	1.02	....	trace		50	1.015	....	....	

AN EXAMINATION OF CERTAIN JAPANESE BRONZES. BY JUGOI TADNARI MATSDAIRA, B. S., '79.

(Course in Chemistry.)

Bronze, as is well known, is an alloy of copper and tin. The relative amounts of its constituents vary according to the purpose for which it is intended; sometimes lead, zinc, gold and silver are added, with the intention of giving it greater brilliancy or fusibility. Modern bronzes differ from the antique ones in composition and manner of manufacture. The bronze coin of Alexander the Great (335 B. C.) contained 86.72 per cent. of copper and 13.14 per cent. of tin. A Roman bronze coin (500 B. C.) contained 66.04 per cent. of copper, 7.66 per cent. of tin and 29.32 per cent. of lead. Most of the modern French bronzes are composed of—

Copper	91	parts.
Tin	2	"
Zinc	6	"
Lead	1	"
	100	"

The Japanese word corresponding to bronze is "Karakane," meaning "Chinese metal." Brass is called "Shin-Chu." The bronze industry in Japan is very ancient. Copper has been produced in Japan since the eighth century, but even before that period the manufacture of bronze had reached a certain stage of perfection, the copper or its alloys having been imported from China. Giyoka, a priest, and the introducer of the potter's wheel, planned the erection of monster statues to the god Buddha, and the plan was carried into execution by the Emperor Shomw in 724–749 A. D. Three of these statues still exist. They are about fifty feet in height, and are said to contain a small percentage of gold.

The modern bronze castings are employed for many useful and ornamental purposes, such as statues, bells, vases, knife-sheaths, candlesticks, &c., and are generally made in the simple and curious style of the old and celebrated Chinese bronzes, or are embellished with the characteristically-grotesque vagaries of Japanese art.

The bronze objects are cast in clay moulds, formed upon models made of a mixture of wax and resin, which is melted and poured out of the mould previous to running the metal in. The melting furnaces are generally of small dimensions, and consist of an iron pot lined with clay.

The surface of the casting is then finished and the design corrected by chiseling. Frequently gold and silver are inlaid to produce artistic effects. This work is known as "Zogan," and is principally carried on in the provinces of Kagan and Techin. Frequently the surface of

the bronze is deadened and darkened by the application of a solution of sulphate of iron and other chemicals.

I have examined two of the best known kinds of bronze. One is called "Shibuich." Its surface is of a light, brilliant grey color, but a scratch reveals a red metal. The object from which I took the sample for analysis, was a knife-sheath. The analysis gave—

Copper	74.11	per cent.
Silver	25.81	"
Gold	.03	"
	99.95	"

The other sample was also from a knife-sheath, and was the metal known as "Shakudo." The surface was a dark rich brown. It contained—

Copper	98.95	per cent.
Silver	.63	"
Iron	.05	"
Gold	.01	"
	99.64	"

THE WELL-WATERS OF NEW BRUNSWICK. BY CONDICT W. CUTLER, B. S., '79.

(Course in Chemistry.)

The analysis of well-water is as much, if not more important than that of the "city supply," for it is the well-water that is generally used for drinking and domestic purposes.

Although well-water is so frequently used in preference to that of the "city supply," still it is often by far the most impure, though it may be clear and sparkling. Well-waters may become contaminated in many different ways. The most frequent, perhaps, is the tendency for a well to act as a drain for the ground in its vicinity. Figure 1 illustrates the drainage of a single pipe having a diameter of only six inches.

A well may thus be considered as a perpendicular drain, and as such we can readily perceive that it becomes a receptacle for all surface-water in its vicinity. One might suppose that a well dug in a sandy soil or clayey soil would be thus subject to impurities, but when constructed through rock or shale it would be entirely free from such contamination. This, however, is not always the case, for although rock may form some protection, still impure waters are often found in wells built entirely through stone.

Figure 2 illustrates how a well in Montclair, N. J., was contaminated from a cess-pool sixty feet distant. As the first few feet of the well was constructed through sandy soil, while the remainder ran through red sandstone, it was thought of course that the impurities

worked their way in through the sand, thus spoiling the water for use. Consequently, that part of the well, down to the sandstone, was masoned up, and a coat of hydraulic cement applied to its outer surface. As no benefit followed, three investigations were made, resulting in the discovery that the water from the cess-pool, sixty feet distant, had worked its way through the cracks of the red sandstone into the well.

Another curious result followed from this investigation, viz., the water drawn from the surface of the well was quite pure, while that drawn from the bottom was greatly contaminated, showing that good and bad waters may exist in a well at the same time, owing to the difference in their specific gravities.

Although the soil in which cess-pools are dug may be able to retain the sewage for a long time, still the ground gradually becomes saturated, and, acting as a sponge, the impure water is carried for many yards until, perhaps, it strikes a well into which it may drain.

Persons living on high ground may suppose their wells to be free from such impurities, not knowing that the barn-yard or cess-pool may be one of the springs from which their water is obtained. (Figure 3.)

Wells constructed in the usual manner (Figure 4) are particularly apt to contain bad water—first, from drainage, as I have just illustrated, and secondly from the decay of animals or reptiles which have fallen in them. The stones lining the wells are so rudely put together that ample room is allowed for toads, snakes, &c., to collect, and hence frequently fall into the water and perish. It is stated by well-diggers that generally they find, at the bottoms of old wells, eight to sixteen inches of mud, containing the decaying *debris* of these unfortunate creatures. It is therefore of the utmost importance that wells be so constructed (Figure 5) that the water may be as free as possible from all drainage and contamination caused by the decay of small animals.

A gentleman recently informed me that he had, for many years, allowed the sewage from his house to flow into an old well. As this well has never filled, the sewage must pass on with the vein of water, which, in all probability, supplies other wells in the vicinity, (Figure 6) from which persons are using the water, little imagining what the strange water supply is which helps feed their wells.

It is almost impossible to construct a well from which water, known to be absolutely pure, can be obtained. Hence, an analysis of well-water is of much importance as the only method of establishing the purity of the water.

The method of analysis used in the following determinations was the one known as Wanklyn's. A portion of the water is partly distilled. The first portion of the distillate contains nearly all the free ammonia existing in the water. This free ammonia is estimated by "Nesslerizing." The residual water is then treated with a mixture of caustic potash and potassium permanganate and again distilled. The distillates contain the ammonia which was in the albuminoid form and

which is also estimated by "Nesslerizing." Lastly the chlorine and total solid residue are determined. [Here follows a detailed description of the method of analysis used, the peculiar difficulties which were encountered, and the means by which they were overcome. This has been omitted, since, from its exclusively scientific nature, it would hardly interest the general reader.—P. T. A.]

The following points will serve to make the results in the table of analyses explicable:

1. Alb. am. alone over 0.1 is suspicious.
2. Free am. alone over 0.1 indicates nothing.
3. Chlorine alone, 5–10 grains, indicates nothing.
4. Total solids alone, over 40 grains—very suspicious.
5. Alb. am. over 0.10, plus free am. over 0.08—suspicious.
6. Alb. am. over 0.10, plus chlorine over 10 grains—bad.
7. Alb. am. over 0.10, plus solids over 40 grains—bad.
8. Free am. over 0.08, plus chlorine over 10 grains—suspicious.
9. Free am. over 0.08, plus solids over 40 grains—suspicious.
10. Chlorine over 10 grains, plus solids over 40 grains—suspicious.
11. Alb. am. over 0.1, plus free am. over 0.08, plus chlorine over 10 grains—bad.
12. Alb. am. over 0.1, plus free am. over 0.08, plus solids over 40 grains—bad.
13. Alb. am. over 0.1, plus chlorine over, 10 grains, plus solids over 40 grains—bad.
14. Free am. over 0.08, plus chlorine over 10 grains, plus solids over 40 grains—bad.

If a water contain over forty grains of solid matter to the gallon, it is generally injurious to health. Such an amount is always suspicious, and demands investigation to ascertain if the matter is organic or inorganic.

When little chlorine is found and albuminoid ammonia is large, vegetable contamination is indicated, but if chlorine is also present, animal impurity is shown.

If much chlorine is found there is reason to suspect the presence of sewage contamination.

Although vegetable impurities do not seem to be as harmful as those of animal origin, still, water containing such contaminations should not be used for domestic purposes, if it can be avoided.

Results of the Analyses of New Brunswick Well Waters.

LOCATION OF WELL.	Solid Residue, in grains, per gallon.	Chlorine, in grains, per gallon.	Free Ammonia, in parts, per million.	Albuminoid Ammonia, in parts, per million.	Date of Collection.
1. College Av. opposite the Grammar School........	35.56	3.9	.032	.070	Mar. 17
2. Corner George and Paterson Sts......................	39.64	3.50	.000	.06	19
3. Albany St. opposite Masonic Hall....................	34.39	3.09	.000	.12	20
4. Corner Church and French Sts........................	27.57	3.90	.052	.086	21
5. Church St. opposite Morgan & Shivler............	36.14	4.25	.324	.130	24
6. Somerset St. near Washington.......................	38.82	5.83	.066	.154	26
7. Foot of Albany St..	62.97	11.13	.064	.076	May 2
8. Foot of Schureman St., on Burnet..................	48.68	8.74	.60	.172	6
9. John St. near Carman......................................	46.64	6.47	.016	.250	8
10. John St. between Hassert and Oliver..............	17.49	1.98	.002	.040	8
11. Corner of Oliver and Neilson Sts....................	33.81	4.66	.002	.100	8
12. Corner of New and Neilson Sts.......................	59.00	6.10	.112	.210	9
13. Between George and Neilson Sts., on Schureman	54.53	6.66	.024	.230	9
14. Corner of Neilson and Liberty Sts..................	66.92	6.06	.080	.206	15
15. Corner of Neilson and Bayard Sts..................	37.31	5.24	.004	.146	3
16. Corner of Neilson and Paterson Sts................	29.38	1.10	.106	.380	10
17. Somerset St. between Water and Neilson.........	79.28	13.41	.010	.280	2
18. Water St. under Penna. R. R........................	202.31	7.98	.014	.192	1
19. Court House grounds....................................	14.69	1.15	.008	.070	19
20. Corner of New and Schuyler Sts.....................	27.98	3.60	.016	.086	20
21. Livingston Av., corner of George St..............	27.28	3.38	.008	.024	16
22. Corner of George and Morris Sts....................	11.16	1.34	.002	.056	17
23. George St. between Commercial and Throop Avs.	33.81	4.50	.026	.146	23
24. Welton St. between Remsen and Livingston Avs.	38.24	4.60	.020	.400	19

Good waters—Nos. 1, 2, 4, 10, 19, 20, 21, 22.
Fair waters—Nos. 3, 11.
Bad waters—Nos. 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 23, 24.

THE GAUGING OF THE RARITAN. BY F. A. WILBER, B. S., '79.

(Engineering Course.)

The importance of knowing, approximately, the quantity of water discharged by a stream whose waters are utilized is well understood, and many of the important rivers of our country have been carefully gauged, and their water supply calculated. In our own State, considerable attention has been paid to this subject, in order to determine the quantity of water, in our northern streams, available for a supply to the cities near New York.

Although the direct, economic bearing of a determination of the amount of water passing our own city, through the Raritan, may not be so evident as a like determination for our northern streams, there is

a question of great scientific interest connected with it. The Raritan drains the region in which the red shale formation occurs, and therefore carries to the ocean whatever waste and removal of soil there may be. Every one familiar with the shale formation is aware that the amount of soil annually removed from the surface of this region, by the rain-fall, is enormous.

This formation is surrounded, or nearly so, by rocks of much firmer structure; and a remarkable feature is, that its surface now lies at a far lower level than that of the surrounding ridges. There is good reason for believing that at some former period the level of the shale was the same as that of these ridges, and the conviction that this was once actually the case, and that, in the course of ages, the action of the elements upon it has reduced its level far below that of the trap and hard sandstone which surround it, forces itself on our minds. The question naturally arises, How long a period has been required to remove the surface of this formation to such an extent? An answer to this question at once suggests itself: If we determine the average amount of sediment in a given volume of the water, and the average annual discharge, we may, with these data, fix an approximate limit to the period of denudation. The object of the work, recorded in this thesis, was to assist in the calculation of the annual discharge. Several determinations, at different stages of water, will be needed to complete this part of the work.

In order to escape any inaccuracy, due to the action of the tide, a spot was selected for the operation, about one and a half miles above the Old Landing bridge. The banks of the stream at this point are nearly parallel, the current parallel to the shores, and the cross-sections of the river bed quite uniform.

In a brief way, and omitting detailed description of operations, I will describe the method employed.

A base or shore line was measured, parallel to the direction of the current, some five hundred feet in length, and the fall of the stream in that distance determined. At each extremity of the base line, cross-sections of the stream were taken at right angles to the base. By means of these cross-sections, a *mean* cross-section was found, and its area and water, or wetted perimeter, determined.

To compute the velocity of the current, we have, according to Weisbach, (see Weisbach's "Mechanics and Engineering," page 965)—

$$(1) \ldots\ldots\ldots\ldots\ldots\ldots V=\sqrt{\frac{F}{ApL}\,2gh}$$

In this formula, V is the mean velocity of the water per second; F the mean cross-section; p the wetted perimeter of the mean cross-section, and h the fall in the distance L—all in English feet. g represents the force of gravity, which in the latitude of New York is 32.16. The co-efficient of resistance is denoted by A, the mean value

of which, for a velocity of 1.5, has been found, by numerous experiments, to be 0.007565. With these substitutions, (1) is reduced to—

$$(2)\ldots\ldots\ldots\ldots\ldots\ldots V=92.21\sqrt{\frac{hF}{pL}}$$

This expression for the velocity may be regarded as exact, when the velocity does not differ materially from 1.5, but is only approximate with velocities which differ considerably from this.

The values of h and L, for this case, were—$h=0.201$ feet, $L=523.38$ feet. The values of F and p, computed from the mean cross-section, were—$F=299.8$ square feet, $p=292.056$ feet. With these values in formula 2 we find, upon performing the necessary reductions, that $V=1.826$ feet per second. Since the quantity of water discharged through any cross-section equals the area of the cross-section multiplied by the velocity, we have, calling Q the quantity—

$Q=Fv=299.8\times1.826=547.435$ cubic feet per second$=32{,}846$ cubic feet per minute.

THE LONG BRANCH IRON PIER. BY GEORGE HILL, B. S., '79.

(Engineering Course.)

Last October a company was formed for the purpose of building an ocean pier at Long Branch. The pier was needed in order to enable steamers to land passengers directly at this favorite watering place, and thus to enable it to compete directly with Coney Island for the patronage of the masses of pleasure-seekers.

Messrs. Macclay and Davies were the engineers, and the plans selected were those of Mr. Job Johnson.

The spot selected, after careful survey of the bottom, was directly opposite the Ocean Hotel.

The pier is built on three parallel rows of hollow, wrought-iron piles. These piles are sunk by forcing a jet of water through them, which emerging from the foot of the pile produces a scour at the bottom, into which the pile sinks by its own weight. As fast as the piles are in position, the iron caps (Plate IV., fig's 4 and 5) are wedged and leaded on; then the girders, with their semi-circular foot-plates, (see Plate III., fig's 2 and 6,) are riveted to the caps; and the structure is then braced transversely and diagonally by the braces shown in the longitudinal and transverse section (see Plate IV., fig's 6, 7, 8, 9 and 10.) Figure 6 is the cross-section for both braces; figures 7 and 8 show the transverse, and figures 9 and 10 the diagonal braces. On the girders are placed the floor-beams, and on these is laid the planking. A glance at Plates I. and II. will make the arrangement of the different parts clear. Plate I. represents the pier in plan and elevation, and Plate II. is a drawing, in cabinet perspective, of the pier, with some of the parts removed to give a better view.

This pier is a departure from the ordinary method of building ocean piers. Its novelty lies in two points—first, that the piles used are hollow, wrought-iron tubes; and, second, that the string-pieces and girders are also hollow and of wrought-iron.

The superiority claimed for it is that it is lighter, stronger and offers a smaller surface to wave-action than any other kind of structure for the purpose.

The usual material for the construction of ocean piers is stone, but this material could not be used at Long Branch for several reasons. The first cost would be too great; the nature of the bottom would not allow of the necessary weight of a stone pier, and any solid structure would be exposed to the tremendous force of the winter gales; a force that has been known to exert a pressure of 6980 pounds to the square foot.

A pier built on piles offers but a small surface to the waves, and having one end of the piles fixed in the bottom and the other connected by the stringers and braces with the abutments, will be able to give somewhat to the pressure applied to it.

But two kinds of piles could be used for this work, viz., wood or iron. Iron was selected for the reasons that it was stronger, in proportion to the surface exposed, and that it was not liable to the ravages of the *teredo* as wooden piles would be.

Referring to Plate I., figures 1 and 2, we see the pier in plan and elevation for 660 feet.

The proposed breakwater is also a novelty. It bears a strong resemblance to a huge gridiron, supported, at an angle of 135° from the direction of pressure, by wrought-iron piles similar to those used in the construction of the pier, the foot of the gridiron being just above high-water mark, and having heavy chains in front of it to break the force of the waves, by destroying their form.

The pier can only be regarded, as yet, as an experiment, for it has not yet been tested by the severe winter gales, to which our Atlantic coast is subject.

Let us now consider the structure of the girders, they being one of the peculiarities of the pier. They are composed of three wrought-iron cylinders clamped together by iron bands. It is claimed for these girders that a vertical pressure of 80 tons on one of them caused a deflection of less than one-half of an inch. Assuming this to be their breaking weight, they seem to me to be much stronger than necessary, as the heaviest load they could be forced to bear would not exceed 150 pounds per square foot, or 12 tons per girder. This would give a factor of safety of nearly seven, if the breaking weight were 80 tons. In reality it is much greater, so that the factor of safety seems to me unnecessarily large, and I think the weight of the girders might be reduced, and their extra weight be put into the piles.

THE RARITAN RIVER IMPROVEMENTS. BY ALFRED B. NELSON, B. S., '79.

(Engineering Course.)

The Raritan river, though small, is none the less of an importance not to be estimated by its length in miles.

It is so small and neglected that it is not probable that one-half of the people of the United States knew anything about it before the appropriations for its improvement were published in the papers, and then they only learned the name and the State in which it is, to forget it again in a few days or weeks.

Yet this river holds no mean position among the navigable streams of our country, as may be seen from Table I. of this thesis, from which we find the total tonnage of the Delaware and Raritan canal for 1871 to be 3,053,857 tons, valued at $40,476,436.90, and the number and classes of boats to be as follows:

Steamers	2,691
Sloops	1,405
Barges	28,772

Canal boats are included with the barges. Besides this there was the tonnage of New Brunswick, which is about 20,000 tons annually, and of South River and the clay beds, besides of numerous docks along the banks, which would amount to 20,000 more.

The Raritan carries more tons and has more boats, of all classes, to pass over its waters than any other river in the United States, excepting the Mississippi, Ohio and Hudson. Is it not, then, high time it was improved? for it needs it badly enough, and has for the last century. It is not only of interest to the citizens of New Brunswick and South River, but it is of national importance.

The Raritan river and Delaware and Raritan canal occupy a nearly central position in that long chain of inland water communication between the States all along the eastern border of our country. It is used by the Eastern and Southern States, as well as by the Middle ones, and almost as extensively. Then how strange it is that it was left so long without improvement, while rivers of minor importance received so much attention and such liberal appropriations.

Not until 1873 were surveys made with any intention of increasing its navigable facilities, and even now only an insignificant sum has been granted for its improvement.

Let us look for a moment at the obstructions which ought to be removed.

We will first see what an obstruction is. We find the Delaware and Raritan canal has a minimum depth of eight feet, therefore soundings in the channel of the river which are less than eight feet, prove obstructions. The minimum width of the channel ought to be 200

feet, in order to allow the large tows, which can just pass the 200 foot draw at Perth Amboy, to move safely above the bridge. Taking these considerations as a basis, we find the following obstructions:

1. A gravel and mud shoal just below the New Brunswick locks.
2. A ledge of rocks 300 feet below the New Brunswick locks, projects into the channel from the south shore.
3. A ledge of rocks 3300 feet above Martin's dock. This is 1200 feet long and 100 wide and runs parallel to the north shore, thus reducing the width of the channel.
4. A reef of rock in the middle of the stream opposite Martin's dock.
5. Shoal water below Widemar's dock and above Lawrence's creek, caused by a deposit of gravel.
6. Near Whitehead's dock is a reef of rock covered with sand.
7. The Middle-ground, an extensive gravel and sand shoal below Crab Island, is due to a sudden widening of the channel.
8. The Stakes present a tortuous, shallow and changeable channel.

The estimates to secure the desired improvements give a total cost of $1,707,042.58.

There has been appropriated, thus far, for surveys and actual improvements, $258,000.

The improvements are to be in the form of dykes, so as to confine the body of water in a narrower channel, thus producing a scour, which in time will carry off considerable of the sediment now deposited in the channel.

Three dykes will be constructed, as shown in Plate I., dyke No. 1 being from Crab Island towards the Middle-ground and will be 1200 feet in length. Dyke No. 2 is a continuation, down stream, of No. 1, and is 6300 feet long. Dyke No. 3 is at the stakes and is 5300 feet long. The top of these dykes is at the level of mean high water.

The general construction of all these dykes is similar, and they are constructed by driving two parallel rows of piling and filling in, with good rubble stone, between them. Heavy timber plates are laid on the tops of the piles, and they are securely braced by cross-braces. Plate II. shows the construction as seen in dyke No. 2. The piles are thoroughly impregnated with creasote before they are driven. Our space will not allow us to describe the method employed for creasoting them.

These dykes will have the effect of increasing the navigable facilities, inasmuch as the main body of the water will be confined in narrower limits; therefore the velocity of the current will be increased, the deposits, which are loosened by the passage of boats, will be quickly carried off by the current, and the channel kept free. This fact has become evident through the building of docks along the line of the river, and the effect will be the same with the dykes to a much greater degree.

Raritan River Trade and Tonnage.

YEAR.	Value of Articles Carried.	Gross Tons, east.	Gross Tons, west.	Gross Tons, total.	Steamers, both ways.	Sloops and Schoon'rs, both ways.	Barges, both ways.
1861........	....	1,260,680	200,628	1,460,308	2,500	1,422	16,325
1862........	....	1,291,465	262,665	1,554,130	2,300	1,600	13,752
1863........	....	1,576,060	349,530	1,925,590	2,887	1,301	12,852
1864........	....	1,634,902	320,218	1,955,120	2,367	918	18,654
1865........	....	1,825,520	352,964	2,178,484	2,305	860	17,172
1866........	....	2,570,027	403,820	2,973,847	2,790	1,303	28,152
1867........	....	2,194,794	381,716	2,576,510	2,541	981	26,811
1868........	....	2,284,352	516,590	2,800,942	1,959	594	20,475
1869........	....	2,319,182	500,262	2,819,444	2,605	605	17,172
1870........	....	2,136,252	445,892	2,582,144	2,876	989	19,560
1871........	$40,476,436	2,647,430	406,427	3,053,857	2,691	1,405	28,772
1872........	....	2,370,409	467,123	2,837,532	2,682	1,204	23,550

VII. THE AGRICULTURAL DEPARTMENT AND STATE FUND.

The operations of the Agricultural Department during the past year are set forth in the accompanying report of the Professor in charge.

The amount of money received from the State Treasurer for the fiscal year ending October 31st, 1879, is six thousand nine hundred and sixty dollars ($6960), which has been expended, as the law requires, exclusively for the salaries of Professors in the Scientific School.

Respectfully submitted,

WM. H. CAMPBELL,

President of the Board of Trustees.

REPORT ON THE AGRICULTURAL COLLEGE FARM, FOR THE YEARS 1878-79.

BY GEORGE H. COOK.

THE SEASONS AND THE WEATHER.

The year which closes with the present month of November has been a favorable one for the growth of farm crops, and for the comfort and health of those who work. The extremes of heat and cold have been less than usual. This can be seen by the accompanying table, showing the highest and lowest temperatures for the different months for several years past, as compared with that for the present year. There were one or two very light frosts near the end of September, and none to kill vegetation till the 2d of November, when there was a temperature of 26°, and some ice formed.

The rain-fall has been so uniformly distributed that no great damage has come from wet weather or from drought. At the end of this season there has been less rain than usual. The following note, prepared and published by P. V. Spader, Esq., of New Brunswick, giving an account of our October weather, is worthy of preservation:

"October was noted for its extreme and long-continued heat—the great range of the thermometer—and its drought. My general observations of the weather extend thirty-three years, and my record of rain-fall eighteen years, and although there have been two occasions when the maximum was higher (October 4th, 1858, and October 6th, 1861, when the thermometer registered 85°), yet these were exceptional days, and I have no record for October which will compare with this for heat and drought. The last rain we had was on Sunday, September 14th. Since then we had light rains on eight days—(September 22d, 0.01; 24th, 0.02; October 9th, 0.02; 19th, 0.07; 22d, 0.02; 23d, 0.01, and 28th, 0.11)—to the amount of 0.30 of an inch. This is also the smallest rain-fall for any month since I have recorded. And yet the grass and foliage did not suffer, as we had excessive rains in June, July and August, and during the whole drought there were heavy dews and a very large amount of moisture in the air. The drought has now continued forty-seven days, and is the longest of which I have any record. The extreme range of the thermometer,

55°, is also noticeable, and the minimum, 28½°, the lowest I have known."

This late drought has given an unusually good opportunity for the depredations of the fly in wheat, and the early-sown fields appear to be somewhat injured. The crops of turnips and cabbage, and the late pasture, are a little shortened.

The tables here given show the average and extreme monthly temperatures for several years past, and also the average monthly rainfall, and with these the temperatures and rain-fall for the months of the year just past.

Temperature at New Brunswick.

MONTHS.	MEANS.		MAXIMUM.		MINIMUM.	
	1863–70. and 1876–79.	1879.	1863–70. and 1876–79.	1879.	1863–70. and 1870–79.	1879.
January	28 deg.	24 deg.	67 deg.	45 deg.	–12 deg.	–8 deg.
February	30	26	62	56	–10	8
March	37	37	77	66	4	20
April	49	45	80	70	30	27.5
May	58	62	93	93	37	41
June	68	68	98	95	46	50
July	75	73	101	98	56	59
August	72	71	97	91	48	58
September	65	62	92	86	42	43
October	54	59	84	84	29	29
November	42	41	74	72	14	14
1878.						
*December	31	31	65	60	1	13

Rain-fall at New Brunswick.

MONTHS.	Average from 1854 to 1879.	1879.
January	3.19 inches.	1.58 inches.
February	3.01	1.80
March	3.25	4.27
April	3.93	2.71
May	4.00	3.84
June	4.12	4.56
July	4.65	1.90
August	5.13	7.86
September	3.35	1.80
October	3.50	......
November	3.46	1.78
1878.		
*December	3.71	4.98
Annual	45.30 inches.	37.08 inches.

*In consequence of this report going to press in December, the year is made to close with November, and the temperature and rain-fall for December, 1878, appear in the tables.

FARM CROPS.

The farm is all under cultivation, except that occupied by the buildings, yards, roads and fish-pond. By underdraining, the whole of it is made dry enough to be cropped in regular succession. Of the ninety-seven and four-tenths acres in the farm, there has been this year in—

Wheat	10	acres.
Rye	3.93	"
Oats	10.90	"
Indian corn	13.88	"
Potatoes	5.84	"
Mangold-wurzels	1.20	"
Carrots	.57	"
Turnips	1.04	"
Cabbage	1.76	"
Clover and timothy	33.96	"
Fodder-corn	3.21	"
Pasture	5.76	"
Garden vegetables	.63	"
Total	92.68	"

Wheat.—A ten-acre field was sown with this grain. It had been cultivated the year before—four acres in potatoes and six acres in oats. The potato field was well manured from the barn-yard. No manure was put on the oat field. The whole field was dressed with Lister's super-phosphate, at the rate of four hundred pounds per acre when sown with wheat, except one acre, which was dressed with fifteen loads of barn-yard manure. Two acres of the potato ground were sown with Clawson wheat, and the remaining eight acres with Fultz wheat. The seed was drilled in. The growth of the wheat was good, with the exception of two or three acres of Fultz wheat, where the ground appears to be not sufficiently drained. The Clawson wheat showed the largest heads and the tallest and heaviest straw.

On threshing we got thirty-nine bushels of Clawson wheat, which is at the rate of nineteen and one-half bushels per acre; two hundred and forty-four bushels of Fultz wheat, which is at the rate of thirty and one-half bushels per acre. The same marked difference in the yield of the two varieties has been found for three or four years in succession.

Rye.—This grain was sowed on ground that had been in fodder-corn, and could not be cleared early enough for wheat. The field was well manured for the fodder-corn, but no fertilizer was used on the rye. Two and one-half bushels of seed per acre was put in. The crop was a very heavy one. It is part threshed, and calculating from this it will be one hundred and ten bushels, which is twenty-eight bushels per acre.

Oats.—Seed of the white Canada oats was sowed this year. The first seed was sent from the Department of Agriculture, and it proves to be a very good variety. It ripens two or three days earlier than the common kind, and yields a little heavier grain and larger crop. The harvest this year was scarcely an average one—the yield per acre is twenty-eight bushels. It was grown on corn ground, and without manure.

Indian Corn.—Three different plots were planted with this grain. One of about three acres, on which turnips were grown last year; one of an acre and thirty-sixth-hundredths, where carrots were first planted and had failed to come up; and the remainder was sod. No manure was used on the ground, except a handful of a compost of plaster, coal ashes and hen manure in each hill at planting. The crop was a very good one, though a little damaged by the heavy blow in August, which bent down most of the stalks and broke off many of the roots, so that some of the ears were a little shrunken. Our whole crop of common corn is six hundred bushels of shelled corn, which is fifty bushels per acre. It is a common belief that corn does not grow well after turnips, but ours this year was quite as good as any we had. The variety we grow, and find adapted to the soil and climate here, is a yellow, twelve-sixteen rowed dent corn that has been long acclimated in this neighborhood. The ears are not large, but they make up in number for the lack of size, and the stalks are not heavy. The crop ripens early. We cultivate it in hills, which are three feet eight inches apart. We have tried it at greater distances, but have not found any advantage in so doing.

The variety planted on the carrot ground was sugar corn, the seed for which was given by the late David Pettit, of Salem. It has been grown upon our farm for three or four years past. On a plot in his garden Mr. Pettit raised of this corn at the rate of two hundred and sixty-three bushels of shelled corn per acre. The soil and the cultivation were undoubtedly of the best, and he was a remarkably skillful farmer; and the amount of the crop as given was attested by some of the best citizens of Salem. The corn is of such superior quality for table use, that in the small plots we have grown it has not yet been possible to hinder the picking of some of it green. This year it was planted at the end of June, and the crop was fifty-five bushels of shelled corn, of fifty-six pounds per bushel, per acre. The dry corn is excellent for feeding to cattle and to fowls. The last bulletin of the Connecticut Agricultural Experiment Station, sent out by Prof. S. W. Johnson, has analyses of corn of the common and sugar varieties. They are as follows:

	Dent Corn.	Mammoth Sugar Corn.
Ash	1.7	2.2
Albuminoids	11.9	14.0
Fibre	2.1	2.7
Carbhydrates	79.0	72.1
Fat	5.3	9.0
	100.0	100.0

The sweet corn contained, on the average, 9.9 per cent. of water, and the common contained 11.7 per cent. The calculated value per hundred pounds is $1.39 for the sweet corn, and $1.22 to $1.31 for the common kinds.

Our sweet corn, shelled and dry, weighs forty-seven pounds to the measured bushel, and one bushel of ears makes twenty-four quarts of shelled corn.

Potatoes.—Most of this crop was grown on sod, and was well manured from the barn-yard. The variety grown was the Early Rose. The amount of the crop was three hundred and forty-one bushels, which is at the rate of fifty-nine bushels per acre. The soil of the farm is heavy and the subsoil is close. It is not well adapted to this crop, and much less ground is planted in it than would be, under more favorable conditions.

Mangold-Wurzels.—This crop has been a partial failure with us this season. The surface of the field in which they were planted is flat, and though underdrained, it did not become dry quick enough after rains, and a portion of the crop was injured so that it was given up, and the ground was plowed and sowed with fodder corn. The remaining part was kept growing, and promised very well, but in August there came a bug on the leaves which entirely destroyed them, and the roots made no farther growth. It was a remarkably fine crop up to that time—two hundred and ten bushels were obtained from about half an acre. The bug was striped like the potato-bug, but much longer and livelier.

Carrots.—These were planted on some of the best ground of the farm. On a considerable portion of the field the seeds did not come up, on account of a hard crust on the surface of the ground, which the young plants were too weak to break through. A part of the field planted with the same lot of seed, on the afternoon before those already mentioned, came up very well, and we had two hundred bushels of excellent carrots on fifty-seven hundredths of an acre.

Turnips.—Only a moderate crop of this root was secured. Both rutabagas and common turnips started well, but the dry weather checked their growth, and finally wilted the leaves so that they withered. The whole crop is two hundred and twenty bushels.

Cabbage.—This crop was a complete failure. The late dry weather so checked the growth that no heads were formed, and the leaves can only be used for fodder.

The carrots, turnips and cabbage are raised for the market of New Brunswick. They are uncertain crops, and though they do in some years pay large profits, they always involve a heavy outlay for labor and fertilizers, and it is doubtful whether we realize as much profit from them as we do from the common staple farm crops.

Clover and Timothy.—The crop of hay was very large and fine. Ninety-one large loads were drawn into the barn from the first crop, and thirteen loads were taken off part of the ground as a second crop, We estimate the first crop at seventy tons of dry hay, and the second at ten tons. In favorable seasons, grass and clover do remarkably well on our soil. Thirteen acres were top-dressed with kiln dust from a malt-house, at the rate of fifty bushels and at a cost of $5 per acre; and from these thirteen acres were taken forty-one large loads of clean timothy hay. There is no doubt the cost of this top-dressing was more than repaid by the increase of this single crop.

Fodder Corn.—This crop is grown largely, and it yields more fodder for the labor and expense involved than any other. It is sown either broadcast or in drills—there does not seem to be much difference in the two ways. It can be can cut at all stages of its growth, but is best when it has matured so far as to have little nubbins of corn on the stalks, and the kernels begin to glaze. By cutting it, and standing it in shocks, like common field corn, it is cured without difficulty, and can then be kept for winter fodder by stacking it in small lots about the yards where needed. We have made no experiments in ensilage, but it is beyond question the cheapest green fodder that can be grown. The experience of many, in our own and in foreign countries, has shown that it can be taken green, packed in pits under ground, and kept for weeks and months without spoiling.

Pasture.—A five-acre field is kept in pasture. Though a good field it can yield but a small part of the food needed for a large herd of cattle, and most of the supply is obtained from various crops which are cut and fed to the cattle in the stables. This pasture is little more than a field for exercise.

STOCK.

Cattle.—The production of milk for market is the leading business of the farm, and the herd of cows for that purpose has been increased during the year. There are now on the farm twenty-nine cows. Besides these an Ayrshire bull, two yearling heifers of the belted Dutch stock,

and five full-blooded Ayrshire heifer calves are kept. The bull, four thoroughbred Ayrshire cows and five calves were shown at the State Agricultural Society Fair at Waverly, as a herd of thoroughbred Ayrshires, and received the State premium of $75.

The cows bought during the year have been of the common stock of the country, many of them being grades of the Devon and Durham breeds.

Swine.—The Jersey red swine which we have had for the past three years continue to give satisfaction. They are healthy and vigorous, will thrive on grass, and with liberal feeding grow rapidly and very large. The stock consists of three breeding sows, a boar, sixteen pigs, and seven shoats for market.

Horses and Mules.—Four horses and a pair of mules are kept for farm work, and to deliver milk to customers in town.

EXPERIMENTS.

The experiments with different fertilizers on Indian corn, have been repeated the past season, using for the purpose plots of one-tenth of an acre each. In the table the results per acre as well as the amount of manure per acre are put down.

FERTILIZERS.	NUMBERS OF THE PLOTS, AND WEIGHTS PER ACRE, IN POUNDS.									
	1	2	3	4	5	6	7	8	9	10
Sulphate of Ammonia	....	300	....	....	....	200	100	200	....	....
Superphosphate of Lime	....	....	500	....	....	300	500	300	500	....
Muriate of Potash	....	....	....	150	....	150	150	....	....	....
Potash Salts	....	....	....	....	....	....	....	150	....	....
Sulphate of Potash	....	....	....	....	....	....	....	....	175	....
Barnyard Manure	....	....	....	....	....	....	....	....	....	32,000
Corn in pounds	3,690	2,200	4,690	4,580	4,190	4,230	4,370	4,950	4,960	5,470
Corn in bushels	51.2	30.5	65.0	63.6	58.1	58.7	60.7	68.7	68.9	76.0
Stalks in pounds	2,950	2,400	3,850	4,020	3,470	4,100	3,850	4,100	3,750	3,900
Cost per acre	....	$12 00	$8 00	$4 50	....	$17 00	$16 00	$13 00	$11 75	$24 00

These experiments were begun in 1872, and have been continued every year since. Their results have been as nearly uniform as could be expected, when the varying conditions of soil, of moisture, and of temperature are considered. They prove that on our soil sulphate of ammonia has no beneficial effect, but that, on the contrary, both corn and stalks are diminished in weight by it, they weighing less on the plot fertilized by it, than on that to which no fertilizer at all had been applied. It appears, too, from these experiments, that phosphates have very little, if any, effect on the growth of the corn or stalks, though they are not injurious. The use of muriate of potash has

been beneficial to both corn and stalks—to the latter more than to the former—and this has been the case so many times that it may be considered as settling the question, and that Indian corn is a potash plant. Barn-yard manure has also been beneficial to both corn and stalks, as is already well known, and the only object in experimenting with it was to have some basis for comparison with the chemical fertilizers.

The fertilizer specially beneficial to wheat is ammonia, though it is improved by the addition of phosphates. That most beneficial in potato manure is potash. Phosphates are essential to the best growth of turnips. Gypsum and calcareous manures are of signal importance for the growth of clover. To this list may be added muriate of potash, as the chemical fertilizer specially adapted to increase the growth of Indian corn.

Experiments on the effect of superphosphate of lime, sulphate of ammonia, and muriate of potash on the growth of wheat are now in progress. Four acres have been fertilized by four hundred pounds per acre of Lister's standard superphosphate, drilled in with the seed. Four acres have been fertilized at the rate of three hundred pounds per acre of the same superphosphate drilled in, and one hundred pounds per acre of muriate of potash sown broadcast on the surface. Four acres have been fertilized with three hundred pounds per acre of the same superphosphate drilled in, and one hundred pounds of sulphate of ammonia per acre, sown broadcast over the surface. Up to this time that on which the sulphate of ammonia was put, is decidedly the best.

THE SOJA BEAN; A NEW FORAGE PLANT.

When in Munich last year, I saw the soja bean in cultivation, as a new crop, and probably a desirable addition to our forage products. It was seen in the grounds of the Bavarian Agricultural Experiment Station, and was in very vigorous growth. The gentleman in charge gave me a few seeds; and seeds of several other varieties of the same plant were procured at Vienna by my friend Mr. James Neilson. We have planted them, and gathered crops of the different kinds this year. The following is a translation of the paper sent out from the Bavarian Experiment Station to those who were growing and testing the capabilities of the plant:

"*On the Cultivation of the Hairy Soja Bean.*—The exertions made in the last decade to naturalize foreign useful plants in Germany, and by their cultivation to increase the income from farm lands, have so far been without result. This has been the case with sorghum, ramie, Siberian fodder, water rice, &c., for each of which great hopes have been excited; but nothing now remains but the remembrance and the proof of the difficulties in the way of our agriculture.

"Fortunately the success of this pursuit depends less on such attempts, than on increasing the quantity of our well-known crops, by good cultivation and heavy manuring—by careful selection of seed and proper care of the plant. All farmers taking these precautions, and using discoveries in these directions, will surely gain satisfactory profits even without new plants.

"Yet the progressive farmer will be interested and make personal experiments, of these attempts at acclimating, if the plant promises to fill some want. We now seem to have such a one for our increasing cattle raising. We need a fodder for young cattle, for milk cows and for bullocks, whose seeds contain, in proper amount, albumen and fat, with a pleasant taste. In cereals and their brans, and also in leguminous seeds, we have fodder containing albumen but not fat enough. The addition of oil-cake is not entirely satisfactory, because the proportion of fat in it varies, and its cost is too great.

"Two years ago Prof. Haberland, of Vienna, an untiring botanical experimenter, introduced to us a plant whose pleasant-tasting seeds are rich in albumen and fat, in very digestible forms. This plant is the hairy soja bean (*Soja hispida, Mönch.*) Prof. Haberland found samples of the seed at the Vienna Exposition among the agricultural products of China, Japan, Mongolia, Transcaucasia and India. He says this plant has been cultivated from early ages. It grows wild in the Malay Archipelago, Java and the East Indies, and is cultivated extensively in China and Japan. Its seeds, boiled or roasted, have a pleasant taste, and form an almost daily part of the food in India, China and Japan.

"The soja is an annual leguminous plant, with a stalk from twelve to eighteen inches high, and with medium three-parted oval-pointed leaves, hairy on both sides. The small, reddish flowers are axillary. The pod is one to one and a half inches long and three-eighths of an inch broad; a stiff-haired, laterally-closed pod, containing two or three oval yellow or brown seeds, the size of the field pea. Its large leaves shade the ground and improve its physical properties.

"In 1876, twenty experiments were made in various parts of Bohemia, Moravia, Southern Austria, Styria, Hungary and Upper Silesia. From the well-ripened seeds from these crops one hundred and thirty-five trials were made the next year under various climatic influences. Prof. Haberland has written us that only twelve of the experiments failed, and most of the results were unusually good.

"According to Professor Haberland there are several varieties of the soja, which vary much in their time of ripening. For the climate of Middle Europe the early kind is best. Sown early in May the seeds mature at the end of September or October. Its time of growth is like that of the horse bean. [This is the *Vicia faba*, the horse bean or Windsor bean of Europe, which is cultivated there for feeding domestic animals, and, like it, ripens after harvest.] It differs from this

bean in its productiveness and its non-liability to harm from insects. It has harvested from thirty-three to fifty-five bushels of seed, and two and one-third tons of very nutritious straw to the acre.

"Prof. Schwackerhofer, of Vienna, has analyzed the original and the harvested seed, and the soja straw, with the following results:

	Original Seed.	New Seed.		Soja Straw.
		1st Crop.	2d Crop.	
Albuminoids	30.56	34.37	34.97	9.43
Fat	15.81	18.25	18.39	2.51
Carbhydrates	33.80	28.32	....	36.03
Fibre	4.67	4.30	....	29.45
Ash	5.12	4.76	....	10.14
Water	7.96	8.62	7.89	12.44

"The following table of the analyses of German broad beans and peas is for purposes of comparison:

	Seeds.		Pea Straw.
	Horse Bean.	Peas.	
Albuminoids	25.5	22.4	6.5
Fat	1.6	2.0	1.0
Carbhydrates	45.9	52.5	34.0
Fibre	9.4	6.4	38.0
Ash	3.1	2.4	4.5
Water	14.5	14.3	16.0

"From these we see plainly that if the soja bean will give sure crops in our climate, we have in it a fodder far exceeding our present ones in practical value, on account of its richness in albumen and fat.

"Professor Haberland's experiments show that the straw is very nutritious, and is eagerly eaten by cows, so that cattle-growing will receive an important aid."

The following directions were sent out with the soja beans for experiment: "We send the necessary seeds, five hundred, asking you to use only the full-grown, perfect ones. There is a mixture of three varieties, brown, yellow and light green, which must be separated and sown by themselves, in parallel rows. The ground for the trial should be four square metres, not too flat on the surface, and of good earth, and carefully protected from fowls, which are very fond of the plant. On each square metre one hundred seeds should be sown in ten rows,

so the plants should be about one-tenth of a metre apart. [This would make the plants to stand almost four inches apart each way.] The sowing should be done the first half of May, and the harvesting, according to local climatic influences, from the end of September to the middle of October. The beans, like the horse bean, ripen after harvesting. * * Please to inform us, in your report at the end of the season, of the character of the soil on the experimental plot, the time of sowing, beginning of bloom, and of harvesting; any harm to the plants from insects, severe storms, continued drought, &c., and the weight of the beans and straw from the four hundred grains sown."

The beans which we had were so few that we planted them in rows about three feet apart, and a foot apart in the row. The soil was a sandy loam, in good condition, and they were planted, without manure, the latter part of May, and were entirely ripe at the beginning of October. They might have been gathered earlier, and the stalks would have been better fodder. Their growth was luxuriant, and the stalks, which are quite branching, are enough coarser than common climbing beans for them to stand up, and their foliage is very heavy, though a little coarse and rough in appearance. We have not made any trials for feeding the crop green, or for testing the feeding qualities of the beans, but have saved them all for seed.

The rows were fifty yards long, and the crops gathered from them were as follows:

1st row—Two quarts of a brown bean, nearly round, from China; well ripened, and would have borne very much closer planting.

2d row—Seven quarts of a light-olive colored, black-eyed bean, from Japan; longer vines and not so well ripened.

3d row—Nine quarts of a dark, greenish-brown bean, from China; not perfectly ripened, very heavy growth of stems and leaves. This and the preceding probably need a warm climate.

4th row—Five quarts of a drab-yellow, pea-like bean, from China. This is well ripened, and would have borne to be planted very much closer.

5th row—One quart like the preceding. The seed was obtained in Munich. For some cause it did not sprout well, and but few plants were grown.

The yield of these is not as large as that given in the Austrian experiment, but it is not discouraging. Another year they must be planted much thicker; and from the instructions given it is evidently expected that they will grow without hoeing or cultivation of any kind.

The advantages of these beans will be better appreciated by an examination of the composition of some of our best-known feeding substances, and a comparison of them with that of these beans. We put timothy hay and clover first in the list, as these are well known, and their three constituents albuminoids, fats and carbhydrates are in such proportion as to keep animals in full flesh and healthy condition.

In computing their values for feed, the prices given by the Connecticut Agricultural Experiment Station are used, viz.:

For one pound digestible albuminoids....................4 1-3 cents
" " " fat.................... 4 1-3 "
" " " carbhydrates.................... 9-10 "

And as there are no data for determining the digestible qualities of the soja beans, the composition of the various substances will be used, and no important error can arise from this.

SUBSTANCE.	Ash.	Albuminoids.	Fat.	Carbhydrates	Comparative value per 100 pounds.
Timothy hay	4.5	9.7	2.2	45.8	$0 93
Clover hay	5.3	12.3	3.0	38.2	1 00
Oats straw	4.0	4.0	2.0	36.2	59
Cured corn-fodder	4.2	4.4	1.3	37.9	59
Indian corn	1.5	10.7	4.9	66.5	1 29
Oats	2.7	12.0	6.0	55.7	1 26
Wheat bran	5.1	15.0	3.2	52.2	1 26
Malt dust	6.71	25.9	1.1	45.5	1 49
Cotton-seed cake (decorticated).	7.6	38.8	13.7	19.5	2 45
Brewers' grains	1.2	4.9	1.6	11.1	36
Horse beans	3.1	25.5	1.6	45.9	1 59
Soja beans	4.8	34.7	18.3	28.3	2 55

In this table the soja bean is shown to have the highest value of any of the substances named, and by mixing it with oat straw or cured corn-fodder, it will make a rich and healthful fodder for cattle, and one which can be afforded in greater quantity and at less expense than first quality timothy or clover hay. It would form, too, a proper crop to be in the rotation between corn and wheat, instead of oats or potatoes, as now practiced. It is not subject to the same difficulties in curing as our common field bean, as the beans do not easily shell out, and coarser stalks enable it to be cured like Indian corn. And being a sowed crop, it is cultivated with the minimum of labor.

TRIALS OF IMPLEMENTS.

Two trials of implements have been made on the farm this season, under the direction of the Middlesex County Farmers' Club. The first was a trial of mowers and reapers, made July 1st. The second was a trial of plows, and was made October 23d. The following are the reports of the committees who had them in charge:

REPORT ON MOWERS AND REAPERS.

In the latter part of June, the President of the Farmers' Club, Mr.

J. V. D. Christopher, influenced thereto by applications from several persons interested in mowers and reapers, called a meeting of the club, and it was resolved to have a trial of mowers and reapers under its direction, on the farm of the State Agricultural College, where both grass and grain had been kindly placed at their disposal.

The committee in charge of the trial of mowers was composed of of Capt. Blish, Messrs. A. N. Conover, Britton Mount and Adrian Vermeule.

The committee on reapers consisted of Messrs. G. W. De Voe, Matthew Suydam, James G. Cortelyou and Ezekiel Silvers.

On Tuesday, July 1st, the committees named met on the farm of the Agricultural College, with the exception of Mr. Ezekiel Silvers.

The field of grass selected for the trial of the mowers was an undulating field of clover, back of the house. A portion of the grass was very heavy and much lodged and intertwined.

Lands extending the full length of the field and about two rods wide were marked off, allowing one plot to each machine. The machines were then put to work successively, and each machine cut the whole of the plot on which it had been started.

Five mowing machines took part in the trial, viz.: The Johnston Mower, the Kirby Mower, rear cut, the Osborne Mower, front cut, the Champion and the New Warrior.

Each machine cut a swath of four feet three inches clear, and no machine was more than a minute and a half getting ready to cut after coming on the ground.

It had been the intention of the committee to have a dynamometer on the ground to test the draft of the machines, but through some misunderstanding there was none, so that the committee were unable to judge satisfactorily of the ease with which the machines were pulled. They therefore decided to confine their conclusions to the general remark that the machines all did good work, with apparent ease to the team, and while the grass was cut closer to the ground by some than by others, yet the work was all satisfactory, all the machines cutting as close as was necessary. It was proved to be possible to choke any machine under some circumstances, but, practically, no reasonable fault could be found with any of them in that respect.

The reapers were tested in both rye and wheat.

Two sides of the rye gave an excellent test for the machines, as the straw leaned over very decidedly, and was somewhat tangled.

The reapers entered were the Johnston, the Royce No. 4, the Kirby No. 3, and the Champion. The work done by these machines was so very nearly equal, that it was difficult to decide which did the best, although some of the committee gave the preference to the Johnston on the worst side of the rye. A field of Fultz wheat was then cut around, one machine following another; and here the work was as nearly perfect as we can ever expect to see.

Every bundle was laid neatly at regular distances, and the stubble was so even that it had the appearance of having all been cut by one machine.

It had been the intention of the committees to make a thorough trial with measurements and notes of draft, but in the absence of the dynamometer, they were reduced to the same means of judging as any spectator, and therefore have declined to make any specific decision of the relative efficiency of the several machines which took part.

Signed,

SAMUEL BLISH,
G. W. DE VOE,
Chairmen of the Committees.

THE PLOW TRIAL.

Mr. Lewis Campbell, Chairman of the Committee of Judges at the trial of plows on the College Farm, submitted the following report, which was read and adopted:

Trial of Plows on the College Farm, October 23d, 1879.

	NAME AND DESCRIPTION OF PLOW.	Average depth of furrow in inches.	Average width of furrows in inches.	Area of cross section of furrow in square inches.	Average draft in pounds.	Number of pounds of draft required to turn a furrow having a cross section of 100 square inches.	Quality of work.
1	Wiard "D" Chilled Plow, malleable iron beam, wheel and jointer ...	6 5-12	13 5-12	86.90	525	604.14	100
2	Syracuse, No. 3, Chilled Plow, Salisbury iron beam, wheel and jointer	6 1-6	13	80.16	533	664.92	95
3	Ten Eick's Clipper Steel Plow, iron beam, jointer and wheel..........	6 2-3	11	73.33	475	647.75	85
4	Dietz Plow, wooden beam and straight coulter........................	6 2-3	10 11-12	72.77	617	847.90	80
5	Stevens Plow, No. 9, wooden beam and straight coulter................	7 7-24	12	87.50	583	666.28	80
6	Common Plow, with sulky attachment..................................	6 5-12	11 1-8	71.38	650	910.62	85
7	Same Plow, without sulky..	6 5-8	12	79.50	658	815.09	85

No. 1, entered by Bennet & Parks, of Jamesburg.
No. 2, entered by Isaiah D. Barclay, of Cranbury.
No. 3, entered by Andrew Ten Eick, of New Brunswick.
Nos. 4 and 5, entered by J. V. D. Christopher, for comparison.
Nos. 6 and 7, entered by Mr. Nishwitz, the inventor.

LEWIS CAMPBELL,
VERDINE E. FARMER,
JOHN M. WHITE,
Committee.

These trials are both interesting and useful. They bring together farmers, and give them an opportunity to see the best implements of their kind, and to see their work when in the hands of those who understand them. They bring together, too, the agents and inventors of

the different machines, and give them an opportunity to study and criticise the implements and work of their competitors. In this way the whole farming community is benefited, and the implements are improved and brought nearer to perfection every year. In the trial of reapers and mowers, the machines present were probably as good as any made in our country, and the quality of the work done in cutting heavy crops of grass and grain was complete. It is a source of pride to every American, to see these labor-saving implements so perfectly replace the manual-labor tools of former times.

The plow trial was between three very good plows, which were exhibited and tried by their friends. They all did well, but the ground was so dry and hard that they could not show the quality of their work so well as they did last year, and the draft was fully one-half greater than then.

The Dietz and Stevens plows were old ones, not in perfect order, and were brought to show how much they were inferior, both in draft and quality of work, to the best plows of the present day. The sulky attachment was tried, to show that there was no increase of draft, nor injury to the quality of work done by the plowman riding and guiding the plow with his feet. This is a labor-saving invention, which allows boys or elderly men to do the heavy work of plowing as well and as easily as it was formerly done by strong men. It was not believed by those who first saw the sulky attachment, that the plow, with it attached, would run as easily as without it, but the trials, last year as well as this year, prove that it does. The one shown this year is the invention of Mr. Frederick Nishwitz, of Millington, Morris county, who is well known as the inventor of the wheel-harrow. He was at the trial, and showed the sulky attachment at work.

There was also shown, at the time of the plow trial, the Acme pulverizing harrow. This is also the invention of Mr. Nishwitz. It is intended to do the work of the clod-crusher, leveler and harrow in one implement. "It consists of a diagonal clod-crusher and leveling-bar or beam permanently secured to the tongue or draft-pole, and provided with a series of spurs. This contrivance, which precedes the harrow, crushes and breaks down the lumps, and, at the same time, levels the surface. To this crusher is hinged a bar or beam provided with a series of sharp, curved steel coulters, which cut, lift and turn the soil."

This implement was tried on the inverted sod which had just been turned, and hard and lumpy as the ground was, it smoothed and pulverized the soil well, and did not turn over any of the sods. The draft was not heavy, and the work done was of a kind that could not be done by the common harrow. We had before tried it on common plowed ground, in preparing it for wheat, and were much pleased with its operation, but the work done was much less difficult than this at the plow trial. This implement is an economical addition to the means of thorough cultivation, and saving of labor. The implement was sent

from the establishment of Messrs. Nash & Bro., of 22 College Place, New York.

Gorton's combined feed-steamer and clothes-washer was also shown in operation by the inventor, at the same time. This apparatus is a very simple form of steamer, and yet was very efficient in working. It is a common base-burning coal stove, surrounded by a galvanized iron jacket, which holds the water to be boiled. It is provided with a simple safety-valve, and a steam pipe or tube to conduct the steam wherever it may be needed, to boil water or to steam or cook feed. It was set up in the building connected with the pig-pens, and a barrel filled with ears of corn and water was placed in the cow-stable, one hundred feet away from the boiler, but connected with it by an inch pipe. The steam from the boiler soon set the water boiling, and the corn was made as soft as green corn. It takes but very little fuel, and any one who can manage a stove can manage this boiler.

DONATIONS.

Messrs. Lister Brothers, of Newark, have made a donation of two tons of their standard superphosphate of lime.

Messrs. Nash & Brother, of 22 College Place, New York, have made a donation of one of the Acme pulverizing harrows.

Mr. C. Gorton, of 4312 Silverton avenue, West Philadelphia, has left at the farm one of his combined feed-steamers and clothes-washers.

The thanks of the Trustees of Rutgers College are tendered to these gentlemen for their valuable donations.

EXAMINATION OF THE SOIL OF THE COLLEGE FARM, AND OF SOME OF THE FERTILIZERS USED UPON IT.

The soil of the College Farm is a clay loam, with some quartz gravel in it, and numerous cobblestones are scattered on and through it. The subsoil is of the same composition, and at depths, varying from two to ten feet, it is underlaid with red-shale rock. This soil is made up, to some extent, from the shale which underlies it, but more from the clays and sands of the lower members of the cretaceous formation, which overlap the red shale at this place. This soil suffers quickly from drought, and under the pelting of rain and the subsequent drying from sun and wind it becomes covered with an uncommonly hard and strong crust. The subsoil is close, so that water does not drain away from it readily, and nearly all of it has to be thoroughly underdrained before it is safe to depend on it for growing good crops. We have seven miles of underdrains on the farm, and some of our most productive fields were only swamps, before the drains were put in.

The composition of the soil is silicious rather than calcareous, and the timber which grew best on the dry portions of the soil was chest-

nut and white pine. In the wetter portions white oak grew well, and the sweet gum was common. On a considerable portion of the farm the spots of wet and dry ground were so intermixed that it was never considered worth clearing for cultivation, until the practice of under-draining came into use.

The following analyses of the soil were made from samples taken from the two ends of the farm—(1) From the north end, just east of the water-works reservoir, and by the side of a fence which has been standing many years, so that this soil has not been tilled or fertilized for twenty years, and probably much longer. (2) Is from the woods at the south end of the farm, and has never been cleared. The samples of subsoil were taken in each case from the same places with the soils, and from a depth of from eight to fifteen inches below the surface:

Analyses.

	(2)		(1)	
	Soil.	Subsoil.	Soil.	Subsoil.
Insoluble substance, mostly sand	83.40	88.60	80.50	84.15
Peroxide of iron	2.04	2.58	4.47	5.10
Alumina	3.31	3.99	6.49	3.94
Lime	.01	.01	.22	.19
Magnesia	.18	.32	.47	.58
Potash	.09	.02	.32	.27
Phosphoric acid	.05	.03	.08	.06
Sulphuric acid	.02	.01	.03	.02
Carbonic acid	.06	.01	.03	.01
Organic matter	7.20	3.50	5.60	4.12
Water	3.00	1.30	1.90	2.07
Total	99.36	100.37	100.11	100.51
Ammonia	.14	.06	.20	.07

These analyses show that in composition the subsoils differ but little from the soils, except in the amount of organic matter and ammonia. They are remarkable for the small quantity of lime in them. The soil (1) has undoubtedly been cultivated in former times, and exhausted. These soils are both of a kind that would yield light crops without manure when first cleared, but they are very soon worn out, unless renovated by the addition of fertilizers.

The quality of the soil will be better understood by comparing its analysis with those of other representative soils in the State. And for this purpose the accompanying table, showing the composition of soils from different parts of the State, has been arranged, and these soils represent the principal varieties found in New Jersey.

1. Is the soil on gneiss and granitic rocks. It is a good and productive soil; many excellent farms are on it in Warren, Hunterdon, Somerset and Morris counties. The sample is from uncultivated land.

2. Soil found in the limestone valleys of Sussex, Warren and Hunterdon. This specimen is from land that has never been tilled, and would probably yield thirty bushels of wheat to the acre without manure.

3. Soil from the red-sandstone region of the State. This is not a rich soil, but is very responsive to good tillage, yielding fine crops when properly fertilized. The sample is from a cultivated field. Such soils are found in Bergen, Essex, Passaic, Union, Middlesex, Somerset, Morris, Hunterdon and Mercer counties.

4. Soil from trap rock—uncultivated. This is naturally not a very productive soil, but there are some good farms on it in Somerset, Hunterdon and Mercer counties.

5. Soil from the marl region. This represents a large body of soil in Monmouth, Burlington, Camden, Gloucester and Salem counties. It is easily exhausted, but is susceptible of great improvement, and the use of marl and other fertilizers has made it the most productive soil in the State. The sample is from wood-land.

6. Sample of miocene soil from Cumberland county.

7. Sample of uncultivated soil, representing the oak-lands of southern New Jersey. This represents a large body of land in Monmouth, Ocean, Burlington, Camden, Gloucester, Salem, Cumberland, Atlantic and Cape May counties. It needs fertilizers to make it fit to grow crops. It is very responsive to manures, easily and inexpensively tilled, and good farms are found on it in various places.

There are many other soils of somewhat limited extent, which differ from these in some of their characters, but the above are sufficient for our comparison.

	1	2	3	4	5	6	7
Insoluble	72.25	74.65	83.25	52.20	88.45	83.10	94.20
Peroxide of Iron	19.57	4.56	4.64	11.32	4.68	2.25	1.13
Alumina		8.73	5.67	23.05	1.67	5.45	2.34
Lime	0.01	0.33	0.14	0.12	0.03	trace	0.02
Magnesia	0.31	0.54	0.31	0.30	0.36	0.74	0.02
Potash	0.13	0.47	0.15	0.19	0.47	0.19	0.04
Phosphoric acid	0.13	0.16	0.09	0.08	0.21	0.05	0.03
Sulphuric acid	0.01	0.02	0.02	traces	0.01	trace	0.01
Carbonic acid	0.02	0.06	0.48	0.02	0.01	....	....
Organic matter	5.85	8.25	4.25	9.50	3.70	6.60	1.40
Water	1.55	1.90	1.25	3.25	1.70	2.00	0.60
Total	99.83	99.67	100.25	100.03	101.29	100.38	99.79
Ammonia	0.04	0.25	0.12	0.03	0.08	0.14	0.05

The substances most needed to make a fertile soil are ammonia, phosphoric acid, potash and lime. If a soil is deficient in any of these, its productiveness is impaired, and the deficiency must be supplied by the addition of fertilizers, or it will not grow large crops. Our soil is evidently deficient in lime, and the potash and phosphoric acid are not very large, so that it needs fertilizers of every kind, in order to enrich it so that it will produce crops to the best advantage.

An acre of this soil (1) from the College Farm contains, within six inches of the surface, one hundred and seventy-four pounds of lime, fifteen hundred and sixty-six pounds of potash, eight hundred and seventy pounds of phosphoric acid, and thirty-four hundred and eighty pounds of the elements of ammonia; and the ninety-two cultivated acres of the farm contain eight tons of lime, seventy-two tons of potash, forty tons of phosphoric acid, and one hundred and seventy tons of the elements of ammonia.

The principal articles of produce sold from the farm are milk and wheat. Of the former we sell about seventy-three thousand quarts yearly, and three hundred bushels of the latter. In these there are contained of—

Lime	95	pounds.
Potash	115	"
Phosphoric acid	266	"
Ammonia	1051	"

Some other products sold may slightly increase these quantities, but in the whole they are only a small fraction of the quantities in the soil. The latter are, however, so locked up in the stony particles of the soil that only a small part of them can be got out in a single year; and it is part of the farmer's art to get as much of them as possible out by means of good tillage and manures which may act in decomposing the particles of soil, and thus liberating these necessary constituents of plants.

It is everywhere observed that there is, in all fertile soils, a small percentage of black vegetable matter, and it is chiefly in this that soils differ from subsoils. Professor Grandeau, of the Agricultural Experiment Station at Nancy, France, has advocated the theory that this black matter is the solvent by which the mineral matters of the soil are released from their combinations, dissolved and brought to the roots of growing plants in proper form to be taken up and assimilated. To prove his theory, he takes soils which are to be examined, washes them carefully in dilute hydrochloric acid to remove the lime, and then, after washing out all traces of the acid, he washes the soil in dilute aqua ammonia, by which the vegetable matter is dissolved out, and appears as a very black fluid. In this fluid the ordinary reagents give no test for phosphoric acid or potash, but when it is dried down, and the residuum burned, these substances appear in the ashes, and can be estimated in the ordinary way.

The College Farm soil, (1) tried in this way, showed, in the black matter of one acre, eighty-five pounds of lime, five hundred and twenty-three pounds of phosphoric acid, and four hundred and thirty-five pounds of potash—enough of each of these substances to supply all that is needed for several crops.

The utility of the organic matter in soils has been recognized by farmers in our own country for many years past. The late Dr. S. L. Dana's book, "The Muck Manual," is still a valued hand-book in the estimation of farmers, and the theory of the action of muck which he advanced corresponds closely with that of Professor Grandeau. In the district of country where the soil No. 2 is found, wheat-growing is a leading object with the farmer, and it is grown successfully without manure if a good crop of clover can be got in the rotation between the successive crops of wheat. In some late failures of the clover crop there, the following crops of wheat have been almost ruined, and analysis has shown that nearly one-half of the organic matter is gone from the soil, while the lime potash and phosphoric acid are not sensibly diminished. The same conclusion, too, is to be drawn from an examination of the analysis of soil No. 5, in which there is a full supply of potash and phosphoric acid, but not enough of lime or of the elements of ammonia. This soil is light and poor, growing at first only middling crops of rye and corn, and being soon exhausted. The addition of calcareous marls, and the growth of clover soon brings it to the highest degree of fertility; and without these no profitable farming can be carried on upon it.

To supply the organic substance in the soil, muck may be used to supplement the manure collected on the farm; and where there is a deficiency in the mineral elements of the soil, as is the case in soil No. 6, these can be supplied most economically from greensand marl. Neither of these alone will give fertility to the soil, but the two together do; one supplies the needed mineral elements, and the other furnishes the elements of anmonia and the solvents to dissolve and prepare the minerals for plant food. When the growth of clover is established it may take the place of the muck. But in any good system of farming provision must be made for an abundant supply of animal and vegetable manures. This is to be done by the keeping of horses, cattle, sheep, or swine, as circumstances may make most profitable, and keeping them in sufficient numbers to consume all the rough fodder grown on the farm, and in many cases all first quality hay, too, selling only meat and dairy products. Where market facilities admit of the purchase of cheap feeding stuffs, such as wheat bran, malt dust, decorticated cotton-seed cake, brewers' grains, &c., the stock of animals may be enlarged, and the quantity of farmyard manure both enriched and increased. A reference to the table of feeding stuffs and their composition and ash, on page 58, will show this. The albuminoids there given contain about fifteen per cent. of the elements of

ammonia, and a large part of them is, after being consumed by animals, returned again to the dung-heap. And the same thing is to be said of the ash or mineral substance, which, in seeds, is chiefly potash or phosphoric acid.

We have consumed on the farm many tons of one or the other of the above feeding stuffs each year, and the effect is to be seen in the increasing fertility of its soil.

THE MAGNETIC DECLINATION.

BY PROF. ED. A. BOWSER.

The *magnetic declination*, or *variation of the needle*, as it is called by surveyors and navigators, is the angle which the magnetic needle makes with the astronomical or true meridian. The latter meridian is fixed; the *magnetic meridian* is the vertical circle coincident with the direction of the needle, and is variable with respect to time and place, since the needle is in a state of continual motion. The variation is called "west" when the north end of the needle points to the west of north. At present the variation of the needle at New Brunswick is 7° 15′ west.

Besides certain *daily* and *secular* disturbances that the needle is subject to, observations continued through a series of years at any place, show a very regular *annual* change in the magnetic variation. A good deal of attention has been given to the subject with the view of ascertaining the *amount* of *annual change*, so as to calculate the magnetic variation at places occupied previous to the present time, as well as to restore former bearings to lines from their present bearings, and conversely. The extensive use made of the compass in the survey of lands, renders a knowledge of the *law of change* in the variation of the needle an object of great importance.

I here quote from a paper which I read before the Middlesex County Historical Society in 1872:

"The earliest information that we can find on the variation of the needle in the United States, is contained in the journal of Hudson's third voyoge, in 1609, when he discovered the Hudson river. According to his journal Hudson took the following observations:

July 3d,	1609,	Bank of Newfoundland	Variation,	17	degrees west
" 4th,	"	Bank of Newfoundland	"	15	"
" 10th,	"	Near Cape Sable	"	17	"
" 25th,	"	Mouth of Penobscot river	"	10	"
" 28th,	"	Farther south, toward Cape Cod	"	5½	"
Aug. 11th,	"	Near the coast	"	11¼	"
Sept. 13th,	"	A few miles up the Hudson river	"	13	"
Oct. 4th,	"	At noon, on the coast	"	6	"

"He says that on the 2d of September, when he was near the Jersey shore, a little below the mouth of the Hudson river, he found the land to haul the compass 8° to the west, and the day before he found

not above 2° west. The most of these observations were made on board the ship, and perhaps all. The iron of the vessel would necessarily influence the needle to an amount which we have no means of estimating, so that the observations are not sufficiently reliable for comparison. * * * * * * * * *

"The variation of the needle in New York, in 1686, according to Mr. Philip Welles, Surveyor General, was 8° 45′ west."

"In New York City the needle was observed to be in nearly a stationary condition about 1685, pointing then 8¾° west of north; it then moved easterly and reached its eastermost digression about 1797, showing at that time only 4° west declination. Ever since this epoch the motion has been westerly, it value being now 7¾° west."

I quote again from my own paper above referred to: "In a deed which I have here, conveying property from Henry Longfield to John Ryder in 1742, and which refers back to 1689, when the land was surveyed and conveyed by the Proprietors, is the bearing of a line as it was in 1689. This line at that time was due north and south. I have recently found the line, not without some difficulty, and measured its bearing, which at present is north, 1½° west."

The bearing just described I measured in 1871, when the variation of the needle at Rutgers College was about 6° 48′ west. As the variation has increased about half a degree since that time, the present bearing of the line must be about north 1° west, which shows that the variation of the needle, in the vicinity of New Brunswick, is now about 1° less than it was in 1689, making the variation in 1689 to be about 8¼° west.

In 1808, George street in this city was laid out between French (now Albany) and Hamilton streets, on a bearing of north, 9½° west. Hamilton street was laid out at the same time, on a bearing of north, 71° east. The bearing of Somerset street in 1808, was north, 71° east.

The bearing of George street is now north, 5° west; of Hamilton street, north, 75° west; of Somerset street, north, 75¼° west; making a difference of 4½°, 4° and 4¼°, respectively, between the present bearings and those of 1808, or an average difference of 4¼°. These streets bound the College Campus, which was conveyed by Mrs. Gertrude Parker at the same time (1808,) to the Trustees of Queens College (now Rutgers,) and very probably have not been changed. The change of 4¼° between 1808 and 1879 shows that the variation of the magnetic needle in 1808 was 3° west, and gives 3′ 36″ as the *annual change* in the magnetic variation, supposing it to have been uniform.

"In June, 1681, the land on the south side of the Raritan river, from New Brunswick to Bound Brook, was sold to John Iniams & Co., by the Indians, and in November of the same year the title to this tract was obtained from the executors of Sir George Carteret. This tract was soon afterwards surveyed and divided into nineteen lots, having about half a mile of river front, and being about two

miles deep. On November 10th, 1681, two of these lots, containing a mile of river front, and two miles deep, or 1,280 acres, were conveyed to John Inians. The boundaries were as follows: Beginning at a white oak on the south bank of the Raritan and on the lower side of the ferry landing (lower side of Albany street); from thence running (No. 1) northwesterly, as the river runs 80 chains to a point near the residence of J. W. Scott, Esq.; thence (No. 2) southwest 160 chains; thence (No. 3) southeast, 80 chains; thence (No. 4) two miles northeast, to the tree from whence it first began."

In 1784 this tract was re-surveyed, and its boundaries then were as follows: No. 2 was north 41° 15′ east; No. 3 was north 52° 30′ west; No. 4 was south 42° west.

The bearings of these lines at present are as follows: No. 2 is north, 45¾° east, or 4½° more than it was in 1784; No. 3 is north, 48¼° west, or 4¼° less than it was in 1784; No. 4 is south, 46° west, or 4° more than it was in 1784. The average difference is 4¼°. If we suppose this to be the true difference, which must be very near the truth, then it follows that the magnetic variation in 1784 was 3° west. But this is what we found, in a preceding paragraph, to be the magnetic variation in 1808.

Hence, in the interval of twenty-four years, from 1784 to 1808, the magnetic variation diminished by the same amount that it increased; and if we suppose that it diminished at the same *rate* that it increased, the magnetic variation must have reached its minimum about the middle of this interval, or about the year 1796, at which time the variation was about 2¼° west, *if the annual change were the same between* 1796 *and* 1808 *that it has been from* 1808 *to the present time.*

The bearings of Nos. 2, 3 and 4, which were taken in 1681, are not sufficiently accurate to be used for comparisons. The readings should have been about 47°, instead of 45°. Either the surveying was loosely done, or the lines run in 1784 were not coincident with those run in 1681.

E. A. B.

Rutgers College, New Brunswick, N. J., Dec. 1st, 1879.

COURSES OF STUDY.

Four distinct courses of study are included in the schedule which follows:

I. A Course in Civil Engineering and Mechanics.

II. A Course in Chemistry and Agriculture.

III. A Special Course in Chemistry.

IV. A Special Course in Agriculture.

During the first and second years the studies of the two full courses are the same, and are designed to furnish a suitable introduction to the pursuit of the higher branches in either.

During the last two years the subjects of Higher Mathematics, Mechanics and Engineering, in the Engineering Course, are replaced by Analytical Chemistry, practice in the Laboratory, and Agriculture in the other. The remaining subjects are pursued by the students of both courses together.

The course of study for the first two years in this Department is arranged so as to be complete in itself. It is especially designed to meet the wants of those who cannot take the entire four years' course, but who desire to fit themselves as Land Surveyors. Students leaving at this period of the course, receive from the Faculty a certificate of their attainments.

Students in this Department have daily practice in Draughting, with exercises and problems in Geometrical Constructions, in Descriptive Geometry, Topographical, Mechanical and Architectural Drawing, and in Graphical Statics. Several students who had acquired sufficient skill obtained positions as draughtsmen in various offices in the city during their course.

Special Students are received, and allowed to take any part of the above course, provided their previous education is sufficient; and particular provision is made for them, especially in the Laboratory, in Mathematics, Surveying and Draughting.

The Special Courses in Chemistry and Agriculture, occupy two years. The Laboratory is open from 9 A. M. until 5 P. M.

Students are instructed in Blowpipe Analysis; Determinative Mineralogy; Analysis of Ores, Minerals, Coals, Waters, Technological Products, etc.; Assaying; Analysis of Soils, Fertilizers, Agricultural Products and Foods; Volumetric Analysis of Gases; Detection of Poisons; Analysis of Urine and Animal Products and Microscopical examinations. The course of study depends to some extent upon the student's future pursuit in life.

MILITARY TACTICS.—In accordance with the requirements of the Law, provision is made in this Department for the study of Military Tactics.

Special provision is also made for students who desire, after completing the regular course of study, to take post-graduate studies.

In connection with the instruction in Agriculture in this Department, the Trustees maintain an extensive model farm, designed to illustrate the principles of agriculture, and also to test by experiment the value of different systems. It is under the charge of the Professor of Agriculture, and *every Wednesday* during term time will be devoted to giving upon the farm explanations of the experiments and their results, to the students in agriculture, as well as to any farmers who may desire to avail themselves of this privilege.

COURSES OF STUDY.

FRESHMAN YEAR.

Exercises during the year in Composition and Declamation. Bible Class Sabbath morning.

FIRST TERM.

1. French. 2. Mathematics—Loomis' Algebra, from Series. 3. Natural History—Dalton's Physiology; Lectures. 4. Rhetoric—D. J. Hill; Lectures. 5. Draughting—Practical Geometry, plane.

SECOND TERM.

1. French. 2. Mathematics—Loomis' Geometry, from Book IV. 3. Natural History—Zoölogy; Lectures. 4. Elocution—Lectures. 5. English Literature—Hadley's History of the English Language;

Morley's English Literature. 6. Draughting—Coloring, Topographical Signs, &c.

THIRD TERM.

1. French. 2. Mathematics—Loomis' Trigonometry, Plane and Spherical. 3. Natural History—Gray's Botany; Lectures. 4. English Literature—Morley's English Literature, and Lounsbury's Edition of Chaucer's Parlament of Foules; Lectures. 5. Draughting—Mapping, with Sections, &c.

SOPHOMORE YEAR.

Exercises during the year in Composition and Declamation. Bible Class Sabbath morning.

FIRST TERM.

1. Surveying—Murray's Manual; Field Exercises and Mapping. 2. Descriptive Geometry—Church. 3. Chemistry—Lectures. 4. Mental Philosophy—Porter's Elements of Intellectual Philosophy. 5. History—Freeman's Outlines. 6. Draughting—Practical Geometry, solid.

SECOND TERM.

1. Descriptive Geometry—Church; Construction of Problems; Navigation and Railroad Curves. 2. Chemistry—Lectures. 3. Mental Philosophy—Porter's Elements of Intellectual Philosophy. 4. History—Freeman's Outlines. 5. Draughting—Intersection of Surfaces, &c.

THIRD TERM.

1. Leveling and Railroad Curves—Henck's Field Book; Field Practice and Plotting. 2. Shades, Shadows and Perspective—Church; Construction of Problems. 3. Chemistry—Lectures. 4. Mental Philosophy—Porter's Elements of Intellectual Philosophy. 5. History—Creasy's Constitutional History of England. 6. Draughting—Linear Perspective, &c.

*

JUNIOR YEAR.

Exercises during the year in Composition and Original Declamation. Bible Class Sabbath morning.

Course in Civil Engineering and Mechanics.

FIRST TERM.

1. German. 2. Analytical Geometry—Olney. 3. Natural Philosophy—Deschanel. 4. History of Civilization—Guizot. 5. Constitutional History of the United States—Text-book (Andrews,) and Lectures. 6. Draughting—Lettering, &c.

SECOND TERM.

1. German. 2. Analytical Geometry, completed; Differential and Integral Calculus—Olney. 3. Natural Philosophy—Deschanel. 4. Political Economy—Bowen and Perry. 5. Constitutional History of the United States—Text-book (Andrews,) and Lectures. 6. Draughting—Shading, &c.

THIRD TERM.

1. German. 2. Calculus completed. 3. Astronomy. 4. International Law—Woolsey. 5. Draughting—Constructions.

Course in Chemistry and Agriculture.

FIRST TERM.

1. German. 2. Analytical Chemistry—Text book, with Laboratory Practice and Lectures on the Theory of Analysis. 3. Agriculture—Lectures at the Farm. 4. Natural Philosophy—Deschanel. 5. History of Civilization—Guizot. 6. Constitutional History of the United States—Text book (Andrews,) and Lectures. 7. Draughting—Lettering, &c.

SECOND TERM.

1. German. 2. Analytical Chemistry—Text book, with Laboratory Practice and Lectures on the Theory of Analysis. 3. Agriculture—Lectures. 4. Natural Philosophy—Deschanel. 5. Political Economy—Bowen and Perry. 6. Constitutional History of the United States—Text-book (Andrews,) and Lectures. 7. Draughting—Shading, &c.

THIRD TERM.

1. German. 2. Analytical Chemistry—Text book, with Laboratory Practice and Lectures on the Theory of Analysis. 3. Agriculture—Vegetable Physiology. 4. International Law—Woolsey. 5. Draughting—Constructions. 6. Mineralogy.

SENIOR YEAR.

Exercises during the year in Composition and Original Declamation. Bible Class Sabbath morning.

Course in Civil Engineering and Mechanics.

FIRST TERM.

1. Mechanics—Tate or Wood. 2. Engineering—Mahan. 3. Chemistry—Lectures on Organic Chemistry and Chemical Physics. 4. Moral Philosophy—Calderwood's Handbook. 5. Draughting—Machinery and Architecture.

SECOND TERM.

1. Engineering—Mahan. 2. Mechanics—Tate or Wood; Bridge Building, Wood; Indeterminate Analysis. 3. Chemistry—Lectures on Organic Chemistry and Chemical Physics. 4. Moral Philosophy—Butler's Analogy. 5. Draughting—Engineering.

THIRD TERM.

1. Engineering—Bridge Building and Railway Practice; Geodesy. 2. Geology—Lectures. 3. Moral Philosophy—Butler's Analogy. 4. Draughting—Theses.

Course in Chemistry and Agriculture.

FIRST TERM.

1. Mining and Metallurgy. 2. Chemistry and Principles of Agriculture—Lectures. 3. Laboratory Practice and Lectures on the Theory of Analysis. 4. Moral Philosophy—Calderwood's Handbook. 5. Draughting.

SECOND TERM.

1. Agriculture—Its Methods and Products. 2. Chemistry—Lectures on Organic Chemistry and Chemical Physics. 3. Laboratory Practice and Lectures on the Theory of Analysis. 4. Moral Philosophy—Butler's Analogy. 5. Draughting.

THIRD TERM.

1. Agriculture—Animal Physiology; Care and Management of Domestic Animals. 2. Geology—Lectures. 3. Moral Philosophy—Butler's Analogy. 4. Draughting. 5. Laboratory Practice and Lectures on the Theory of Analysis. 6. Thesis.

SPECIAL COURSE IN CHEMISTRY.

FIRST YEAR.

FIRST TERM.

1. Elements of Chemistry—Text-book and Lectures. 2. Blowpipe Analysis. 3. Thesis.

SECOND TERM.

1. Physics and Chemistry—Text-book and Lectures. 2. Chemical Analysis—Qualitative, Practice and Theory. 3. Thesis.

THIRD TERM.

1. Chemical Analysis—Qualitative and Quantitative. 2. Lectures on the Theory of Analysis. 3. Vegetable Physiology. 4. Elements of Mineralogy. 5. Thesis.

Journal of Travel and Observation.

SECOND YEAR.

FIRST TERM.

1. Chemical Analysis—Analysis of Minerals, Ores, &c. 2. Mineralogy—Determinative. 3. Thesis.

SECOND TERM.

1. Chemical Physics—Heat, Electricity, Magnetism, Galvanism and Electro-Magnetism—Text-book and Lectures. 2. Analysis of Fertilizers and Chemical Products. 3. Thesis.

THIRD TERM.

1. Lectures on Geology. 2. Chemical Analysis—Experimental Investigations. 3. Dissertation.

SPECIAL COURSE IN AGRICULTURE.

FIRST YEAR.

FIRST TERM.

1. Algebra. 2. Geometrical Problems. 3. Inorganic Chemistry. 4. Physiology and Zoölogy.

SECOND TERM.

1. Geometry. 2. Coloring and Topographical Drawing. 3. Analytical Chemistry. 4. Mineralogy. 5. Book-Keeping.

THIRD TERM.

1. Trigonometry. 2. Mapping. 3. Analytical Chemistry. 4. Botany. 5. Farm Accounts.

SECOND YEAR.

FIRST TERM.

1. Surveying. 2. Projections. 3. Natural Philosophy. 4. Study of Domestic Animals. 5. Systematic Agriculture.

SECOND TERM.

1. Navigation and Nautical Astronomy. 2. Architectural Drawing. 3. Physics. 4. Geology. 5. How Crops Grow.

THIRD TERM.

1. Leveling and Road Making. 2. Machine Drawing. 3. Meteorology. 4. Botany. 5. How Crops Feed.

Composition and Declamation throughout the whole course.

The hours of lectures or recitations are four each day, besides work in the Chemical Laboratory.

Students who pass their regular examinations in the above subjects, will, at the close of their course, receive certificates of their attainments. And at the end of two or more years further, if they shall have pursued practical agriculture on a farm, and shall then pass satisfactory examinations in prescribed subjects on Agricultural Principles and Practice before a Board of Examiners of the Scientific School, they shall receive Diplomas in Agriculture.